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Bell Telephone MAGAZINE

Distribution by Western Electric Company
ALVIN VON AUW

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and THOMAS SHAW

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A Medium of Suggestion & a Record of Progress

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WALTER S. GIFFORD, *Pres.;* CARROLL O. BICKELHAUPT, *Sec.;* DONALD R. BELCHER, *Treas.*

Who's Who & What's What

in This Issue

SINCE his previous appearances in these pages,* ALVIN VON AUW has covered a lot of new territory, most of it by courtesy of the United States Navy. After seeing action as Air Combat Intelligence officer with a night air group in the first carrier raids on the Tokyo area and after surviving the battering his ship, USS Saratoga, took while supporting the operations at Iwo Jima, Mr. von Auw was released from active duty as Lieutenant, USNR, and resumed his post as information supervisor in the Public Relations Division of the Western Electric Company. Since his return, he has written a number of booklets about Western Electric functions for employee and general distribution, and has been active in the company's motion picture program. Before coming to Western Electric in 1939, von Auw served briefly as managing editor of Listeners' Digest.

* See "Western Electric: Telephone Arsenal," MAGAZINE, August 1941; and "Doing a Bigger Job—with Less," MAGAZINE, August 1942.

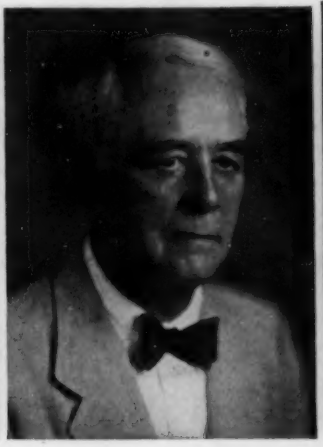
IT WAS as a clerk that Keith S. McHugh joined the A. T. & T. Company in 1919, but within a few months he became an engineer in the O. & E. Department. From 1921 to 1925 he was general commercial engineer of the Chesapeake and Potomac Telephone Company in Washington, D. C., and for the next four years he was with the New York Telephone Company as general commercial manager and as vice president. In 1929 he returned to A. T. & T. as commercial engineer, and was appointed an assistant vice president in 1934. He was elected a vice president in 1938, and in 1946 was placed in charge of the Information Department. He contributed "War Activities of the Bell Telephone System" to this MAGAZINE for November 1942; was one of the authors of "The Bell System's Interest in Program Television" in the issue for Spring 1944; and his farewell to radio broadcasting station WEAF appeared in the Autumn 1946 issue.

Alvin von Auw

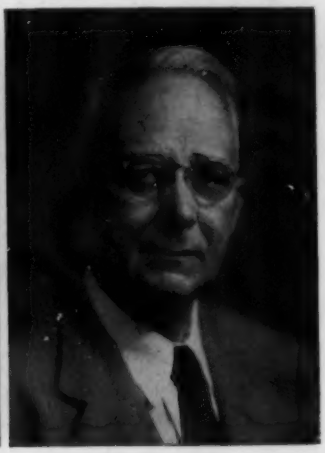
Keith S. McHugh

John R. Townsend

Carroll O. Bickelhaupt



Roger B. Hill



Thomas Shaw

"RESEARCH REVOLUTIONIZES MATERIALS" is the title of one lecture which JOHN R. TOWNSEND has given recently. It might almost serve as title for his contribution to this issue, were it not that he has narrowed his field here a bit to take in only the use of plastics in the telephone business. The title of another lecture, "Materials Engineering at Home and Abroad," is also particularly apt, because Mr. Townsend has been since 1945 materials engineer at the Bell Telephone Laboratories. For 20 years before that he had been materials standards engineer. He joined the Bell System in 1919, after military service in World War I. In World War II he assisted on many technical problems for the Armed Services, the Office of Scientific Research and Development, the War Production Board, and others. In 1945 he spent two months in England, France, and Germany for the Foreign Economic Administration. Mr. Townsend has written and lectured extensively on technical subjects, and is a member of several scientific societies. He was awarded the Dudley Medal in 1930 by the American Society for Testing Materials, and served as president of that organization last year.

THE TWO distinguished careers—civilian and military—of CARROLL O. BICKELHAUPT are linked through the common interest of communication. Joining the A. T. & T. Company in 1911, Mr. Bickelhaupt had served as toll rate engineer, toll traffic engineer, and commercial engineer there before he was elected vice president in charge of operations of the Southern Bell Telephone and Telegraph Company in 1925. Five years later he returned to A. T. & T. as assistant vice president. He was elected vice president in 1941, and secretary of the company in 1945. Meanwhile, through two wars, he had risen in the Signal Corps from first lieutenant in 1916 to brigadier general in 1944. Before Pearl Harbor, he was on active duty as Military Observer abroad, and after the declaration of war he served in the Office of the Chief Signal Officer and later as Commanding Officer of the Eastern Signal Corps Unit Training Center before being promoted to brigadier general and ordered overseas in September 1944. There he was successively Director of Communications Division, Office of Chief Signal Officer; Director General, Signal Communications Service, ETOUSA; and Director of Communications, U. S. Group Control Council (Germany). He returned to this country and inactive Army Reserve status in 1945, and was re-commissioned brigadier general in the Reserve

(Continued on page 176)

In a scene which is duplicated innumerable times each day in Western Electric distributing houses from coast to coast, a stock selector adds more telephone material—dials, in this instance—to the items ordered by a telephone company which are flowing down warehouse conveyor lines on their way toward service. *See the article beginning on the opposite page*

Western Electric's Coast-to-Coast Chain of Distributing Houses Contributes Much to the Efficiency and Economy of Bell System Service

Distribution by Western Electric Company

Alvin von Auw

A MILITARY TERM, "logistics," best describes the business of Western Electric's chain of distributing houses. Theirs is a major role in the big job of moving telephone material to the front line of telephone service.

To fulfill their part in the Bell System logistic set-up, the distributing houses maintain stocks of those items which are recurrently ordered by the telephone companies, items which range in size and variety from paper clips to the heftiest reels of cable. But the distributing houses are concerned with more than the stocks they carry on their shelves. Their responsibilities extend, in fact, to every single item the telephone companies order from Western Electric. These include those items not ordered with sufficient frequency to warrant stocking, as well as major items which must be manufactured to fit a special need—central office equipment, for instance. In short, what the distributing houses don't have, they get.

Each distributing house also maintains a repair shop which reconditions used telephone company material for re-issue, or disposes of it for salvage.

But a bare statement of the threefold function of the distributing houses—warehousing, service expediting, and repair—provides only an inkling of the job they do. For a true view, let us watch a distributing house in action.

Suppose we start in the office, where the orders are received. It is a large, well-lighted room, a busy room somewhat reminiscent of a metropolitan newspaper's city room. There is the same pealing of telephone bells, the same sound of fast-tempo typing, the same murmur of a score or more of telephone conversations. And the resemblance goes

deeper than what meets the eye and ear. Just as a news story proceeds in orderly fashion from reporter to rewrite to city editor to composing room, so a telephone company order is written up and "edited" before it is passed to the warehouse to be filled.

Most telephone company orders reach the distributing house on standard order forms listing the descriptions of the items most commonly used. Telephone company field forces need only fill in the quantities required. Western Electric edits the order on receipt, separating the items known to be in stock from those which will be shipped direct to telephone company locations from merchandise stocks at Western Electric's Works or from outside suppliers.

The Bell System's "General Store"

NOW LET'S FOLLOW a telephone company order from office to warehouse. Here is a Bell System "general store." But no crossroads community ever boasted a general store like this one. The stock embraces thousands of different items—some ranged on racks, some stored in big bins, some stacked in massive array on the floor. Here are nuts and bolts and nails. Here are telephone instruments and hundreds of miles of wire. Here are pencils and typewriter ribbons. Here—in the yard outside the distributing house—are reels of cable of nearly every size and description Western Electric makes. Here are crossarms and outside plant hardware.

Long famed for the variety of its merchandise, the general store more than meets its match in the Western Electric distributing house. The distributing house has but one customer, the Bell telephone company it serves; yet its stocks must and do include almost every variety of equipment and supplies that telephone company employees require for their day-to-day jobs.

The general store that is the Western Electric distributing house is mechanized, too. Conveyors and electric trucks help speed orders to completion.

LET'S WATCH the conveyor and see how an order is handled: an order that come in from the telephone company within the hour.

It calls for a miscellany of small items, and will be filled from stock. The warehouseman at the head of the conveyor scans the order, estimates its bulk, and sets the required number and sizes of shipping containers—together with the order—on the conveyor, where it joins a continuous parade of other orders, each with enough "headway" to be well clear by the time the next order reaches the stock selectors.

As far as possible, items are arranged in racks beside the conveyor in the same sequence in which their descriptions are listed on the standard order forms. Thus, as our order reaches the first stock selector, he selects the first items required from the racks and sets them in the containers as they move slowly past his position. So does each succeeding stock selector, until the order is complete. Finally, at the end of the line, a telephone company employee checks the contents of the container against the order. Then, sealed and addressed, the order is set for shipment.

This view from the rear shows not only a Western Electric distributing house but, at the right, part of its cable dock and, in the foreground, the telephone company's garage

"Shop Talk"

ADD "SHOP" to "office" and "warehouse," and the picture of the Western Electric distributing house is complete. In the repair shop, apparatus withdrawn from service and returned by the telephone company is reconditioned and readied for a new term of service. Repaired material, returned to the warehouses, is ticketed prominently with green labels to indicate that it is telephone company property—Class "C" material, in distributing house parlance.

Repair operations in the distributing house range from work on the simplest types of plugs and cords to work on switchboards and teletypewriter apparatus. Equipment received at the repair shop is carefully inspected and the usable parts separated from those no longer usable. These latter are segregated for salvage. Switchboards no longer serviceable are a source of salvage, too. Repair shop employees "mine" their innards for usable components—relays or resistances, for instance. Such "mining" is a measure not only of economy but also of relief during times of stringent shortages.

In the repair shop you'll find a small-scale telephone assembly line from which veteran sets emerge ready —both in appearance and performance—to take their places in service beside the latest products of Western Electric factories. Worn parts have been replaced by new. Powerful jets of air have blown interiors free of dust and lint. Sets scarred in service leave the repair shop as bright and shining as the day they were born.

A Nation-wide Chain

THERE ARE 29 Western Electric distributing houses, each one strategically located with relation to the needs of the individual Bell telephone company it serves. Here is the coast-to-coast roster: Boston, New Haven,

New York, Brooklyn, Newark, Philadelphia, Pittsburgh, Washington, Atlanta, Louisville, Jacksonville, New Orleans, Detroit, Cleveland, Cincinnati, Indianapolis, Chicago, Milwaukee, St. Louis, Kansas City, Dallas, Houston, Omaha, Minneapolis, Denver, San Francisco, Los Angeles, Seattle, Portland.

Total employment throughout the distributing chain tops 7,000. As of today, the smallest house employs 53, the largest, 1,188. But whatever the size of the operation, the functions and general organization of all the distributing houses are identical. At each main house a stores manager, service manager, and shop superintendent comprise the manager's staff and supervise, respectively, the ordering and warehousing, the service expediting, and the repair functions of the house.

We have visited the shop and the warehouse, the respective domains of the repair shop superintendent and the stores manager. Now let's stop at the service manager's desk. Chances are we'll find him absorbed in a series of telephone talks with one of the merchandise organizations at Western Electric's Works on the one hand and the telephone company on the other. Linking factory and field, the service manager helps coördinate Western Electric deliveries with telephone company operating needs. His responsibility includes not only the material which passes physically through the distributing house, but also that which the house orders for shipment direct to the telephone company.

A stock selector (rear) picks out items which the telephone company order specifies, and places them in containers on the conveyor. Efficient arrangement of the stock assures fast and economical handling and shipment

The Houses as Coördinators

THE DISTRIBUTING HOUSES play a prominent part in the over-all job of coördinating Western Electric manufacturing and Western Electric buying with the anticipated needs of the telephone companies.

As Western Electric material moves along the chain of supply to the

telephone companies, a current of information on telephone company requirements moves in the opposite direction, helping Western Electric establish an orderly and adequate program of production and purchasing. To assist in this program-planning operation, the telephone companies submit to the distributing house managers estimates of their requirements for but a few basic items. From their experience of past requirements and their knowledge of the material normally associated with these basic items, the distributing houses fill out the telephone companies' skeleton forecasts. It is these forecasts which form the foundation for Western Electric's forward program.

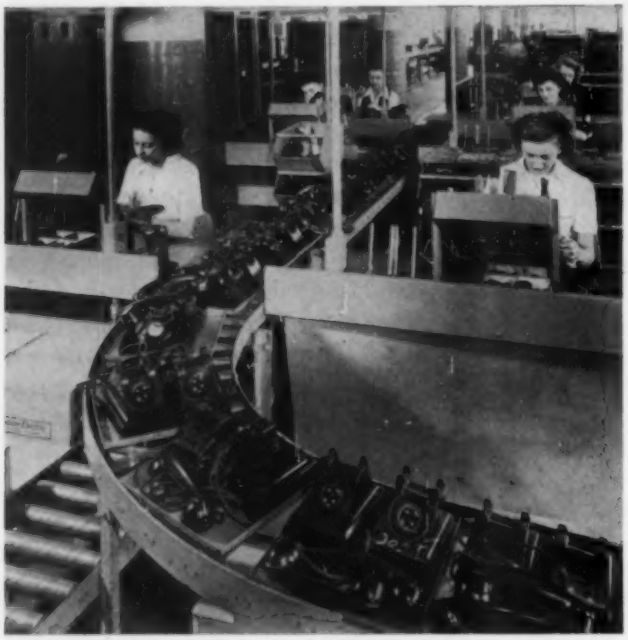
The Service Motive

MERCHANDISING, but with a difference—that is Western Electric distribution. Since each distributing house serves but one customer, the telephone company—and since Western Electric, as a fellow-member of the Bell System, shares the interests and objectives of that telephone company—the energies which might otherwise be expended in a costly sales effort are, in the present instance, devoted to *service* effort on telephone company orders. Thus it is that you will look in vain for a "sales manager" on the distributing house staff—a fact which will serve to point up the principal difference between Western Electric distribution and most other merchandising operations.

The prime motive of most distributors is profit. By contrast, service comes first with Western Electric's distributing organization. As a matter of course, the distribution houses adopt and employ those methods and procedures which best meet the needs of their customers, the telephone companies, and thus contribute at the same time to the over-all efficiency and economy of Bell System operations.

"Direct distribution" is a case in point. Direct distribution—not to be confused with direct shipment from factory to telephone company—is warehouse parlance for the preparation and shipment of small quantity orders for the use of individual telephone company plant men.

WITH THE INCEPTION and expansion of the direct distribution program, the telephone companies have been able to dispense with their storerooms in many areas and to rely entirely on the W. E. distributing house to supply the day-to-day needs of their plant forces. Under this system, the individual worker orders the equipment and supplies he'll need for tomorrow's job. On the morrow he'll find all his working wants waiting for him in his truck. This service, generally available within a given radius of the large centers where distributing houses are located, not only reduces the number of storerooms the Bell System must maintain, but also eliminates the congestion and delay inevitable when a whole shift of men report to draw their supplies in person. For Western Electric it may mean the selection and packing of as many as 4000 items in a single day at a single distributing house. But improved service, and the over-all economies to the System as a whole, make direct distribution worth while.



Repairing telephones for re-use—an important part of distributing house repair shop operations

The Size of the Job

TIME NOW for some statistics to show the size of the job the distributing houses do.

Take a typical distributing house. This house maintains a stock of 8,500 *different* items for telephone company use. In a recent month the house selected from its stock and shipped to the telephone company it serves some 52,491 items valued at $1,133,900. In addition, this house billed the telephone company for 8,453 items, valued at more than $3,100,789, for shipments made direct from sources of supply.

That month, less than two percent of the items normally stocked by all of Western Electric's distributing houses were not available for immediate shipment—an impressive record in this era of shortages but one with which distributing house people are not content. Their pre-war standard, which they aim to achieve again, insists that out-of-stock items shall not run more than three-quarters of one percent of the total of items normally stocked.

More than fifty million dollars' worth of urgently needed telephone apparatus and supplies was restored for further service by distributing house repair shops during 1946. To the more than four million new telephones Western Electric produced last year, the distributing houses added two million reconditioned sets of every description—a contribution of the first magnitude to the Bell System roster of held orders.

Advantages of Common Management

WHAT SERVICES do the distributing houses provide, then, that the telephone companies could not as readily perform for themselves? What are the advantages of a common, centralized management for all 29 distributing outlets?

The distributing house functions could, of course, be performed by the telephone companies—and were, in fact, until something less than a half-century ago. But in the course of business evolution these functions

were transferred to Western Electric to be operated under a common management. Two sound business reasons motivated this transfer: (1) to improve service to the telephone companies and thus to their customers, (2) to reduce costs.

First of all, the transfer of the distributing function—and the purchasing function as well—permits the telephone companies to concentrate their energies on their main job, telephone service, leaving the highly specialized business of distribution and repair shop work to an organization specifically trained for the job.

A switchboard section is reconditioned in a house repair shop for further useful service

Under a unified system of distribution, each employee at each distributing location has a nationwide horizon of opportunity. Since all are schooled in the same efficient distribution techniques, employees transferred from one location to another may apply their experience directly to their new jobs with a bare minimum of adjustment and additional training. If, on the other hand, each distributing location were independently managed and if each trained its employees in its own individual techniques and procedures, the cost of Bell System distribution would be higher and service slower.

SUCCESSFUL SERVICE by the distributing houses is most dramatically demonstrated in emergencies. For in Western Electric's chain of distributing houses, all stocking standard supplies, all employing the same stores methods, the Bell System has a line of supply of proved flexibility in time of crisis. This distributing chain can bring to bear at any point where emergency might strike the full resources of the entire nationwide organization.

Take that fire in River Grove for example.* The devastated central office, serving nearly 10,000 telephones in that Illinois community, was still smoldering as the Chicago distributing house started truckloads of equipment toward the fire scene. Spurred by telephoned orders from the distributing house, the Kearny Works, 900 miles away, and the nearby Hawthorne Works, that very

* See "Crisis in River Grove," MAGAZINE, Winter 1946–47.

day started more truckloads of equipment toward River Grove to fill the communications breach. That River Grove's communications were completely restored in a record-breaking 11 days is attributable in part at least to the coördination of telephone company needs with Western Electric deeds. This was made possible by the ability of a single distributing house to mobilize Western Electric resources, near and far, to meet the emergency needs of its single customer, the Illinois Bell Telephone Company.

LESS DRAMATIC but equally evident are the routine contributions of the distributing houses to the day-to-day job of providing good telephone service at least cost.

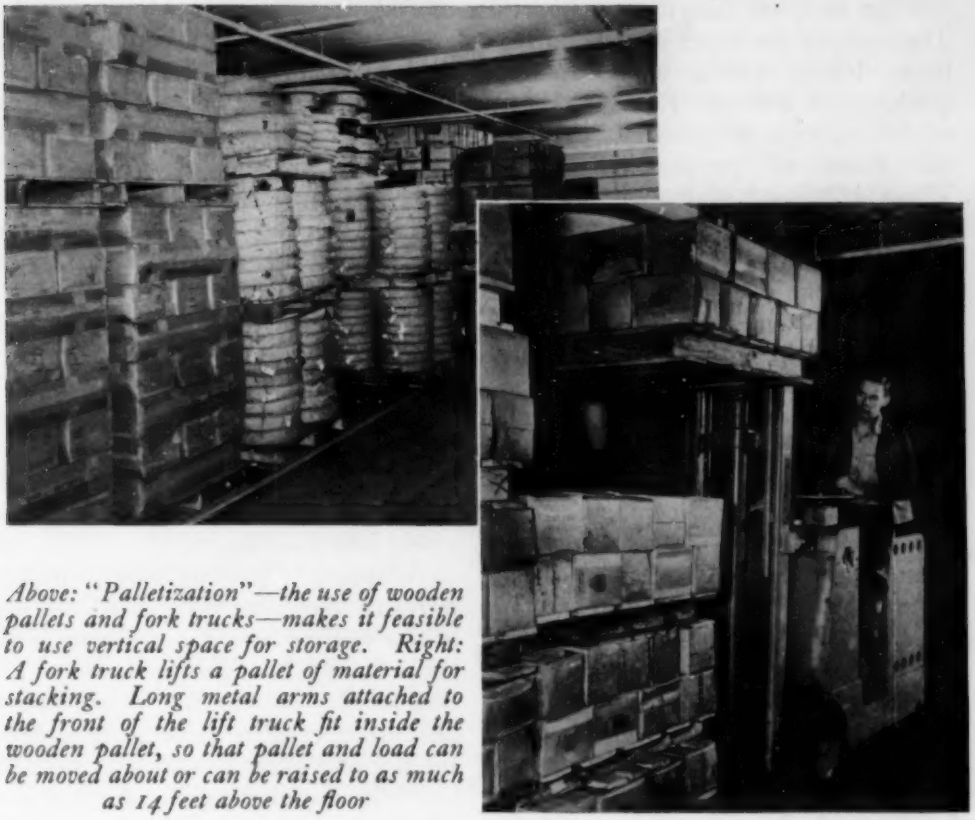
Good service with a minimum of investment in supplies is the governing consideration for Western Electric's unified distributing organization in its big job of providing the Bell System with the materials it needs to operate throughout this great nation.

Since each distributing house may draw on stocks of material at any of the distribution points throughout the country, it can furnish its telephone company with a higher percentage of needed items than if that telephone company were entirely dependent on its own stock reservoirs. And should overstocks accumulate at one house, other houses may draw on these stocks with a consequent reduction of idle investment. In addition, Western Electric circulates to all the telephone companies a centralized record of high-value items taken out of service (switchboards, station apparatus, etc.) and no longer required in the area from which they were removed. This record facilitates the transfer of such items from points where they have only junk value to points where they can be placed in effective service—another blow against idle investment.

Through centralized control of distribution, the performance of each house can be measured and improved by reference to the performance of others. To this end the so-called "red book"—its somewhat forbidding title: *Distributing House Volume and Operating Ratios*—reviews monthly the accomplishments of each house for each major cost and service factor: promptness of shipment, percentage of out-of-stock items, status of back orders, and merchandising expense. This volume is under constant scrutiny for conditions which may call for improvement.

DISTRIBUTION by Western Electric, a nationwide organization, permits expediting deliveries on a national scale. For example, personal contact by the Boston distributing house with suppliers in New England speeds deliveries to a telephone company across the country. Such service is both a convenience and a great economy for a telephone company, which might otherwise find it necessary to send its own representative on a cross-country expedition.

Similar economies derive from the nationwide supplies inspection force maintained by Western Electric's distributing organization. This force inspects Bell System supplies in the manufacturers' own plants. Any failure to meet specifications can be spotted at the source—and corrected. Working in behalf of all the Bell telephone companies, these front-line



Above: "Palletization"—the use of wooden pallets and fork trucks—makes it feasible to use vertical space for storage. Right: A fork truck lifts a pallet of material for stacking. Long metal arms attached to the front of the lift truck fit inside the wooden pallet, so that pallet and load can be moved about or can be raised to as much as 14 feet above the floor

observers employ uniform inspection standards, thus eliminating wasteful duplication of inspection effort by each company. This arrangement simplifies the supplier's problems, too, enabling him to operate with minimum confusion, minimum cost.

New Tools and Methods

THE DEVELOPMENT of new and better methods and tools for distribution and repair is the concern of a central organization of specialists whose accomplishments contribute to the improvement of service to every Bell telephone company by every distributing house. Through the efforts of these specialists, each telephone company gets the benefits of a far-reaching program of distribution engineering which no one of them could economically support alone.

As Western Electric's manufacturing engineers devise new and better ways of making telephone products, so these "engineers of distribution" develop and design the special equipment—the tools, gauges, and test sets for the distributing house repair shop, the tabulating equipment for the office, the conveyors and material handling equipment for the warehouse—which contribute to the efficient distribution and repair of those telephone products.

Conspicuous among the contributions of these engineers has been the introduction of machine billing at all

but the smallest distributing houses. The uncanny machines in distributing-house billing rooms turn out bills quickly and accurately on the basis of information supplied to them in the form of pre-punched cards. These bills and statements are set forth in the telephone company's own accounting terms and are checked by the telephone company's own invoice supervisor, who is stationed at the distributing house. Thus the telephone company can make charges directly to its various accounts without further computation or summarization.

Western Electric engineers contributed materially to the development of these machines. The manufacturer pays royalties on a number of Western Electric-developed features.

"Unit packaging" is another subject of constant study by distribution engineers. The final shipping containers employed by the distributing houses embody a careful consideration of factors of shape, size, and weight, to make handling and storing easier. "End use" governs the design of small-quantity containers for individual telephone company plant men—the objective: to minimize the number of times the package must be opened to select and count material from its contents.

Handling Materials

THE "UNIT LOAD" METHOD of materials handling, made practicable by the introduction of the pallet and the fork lift truck (see illustration on page 121), has been the subject of study and experiment by W. E.'s distribution engineers since our Armed Forces demonstrated the advantages of this revolutionary technique by their phenomenal accomplishments during World War II.

A pallet consists of a double-faced platform a few feet square and a few inches high with open ends, on which materials may be piled. The two surfaces permit the stacking of one pallet load upon another. A fork lift truck is a small self-propelled vehicle with flat protruding forks in front which may be elevated and lowered. Inserted between the faces of a pallet, the fork can lift pallet and load and maneuver them until they are lined up above a stack or other location and then lower them accurately into position.

Adapting "palletization" procedures to telephone materials handling is now well advanced, and the tools of the technique have been supplied to all distributing locations. While many difficulties remain to be surmounted, the use of pallets has already proved itself in distributing house practice. The time, space, and money savings already evident call for a continuing expansion of this program.

Repair-shop equipment developed by the engineers of Western Electric's distribution organization includes a water-wash paint-spray booth, portable self-contained exhaust and dust separators, individual test current-converter units, telephone test sets, tubular fuse test sets, and PBX test sets. And these are but a few among hundreds of developments which, through the years, have reduced the cost or improved the quality of distributing-house repairs. Not many of these hundreds could have been accomplished if common management had not channeled the experience of all 29 repair shops into

a single central engineering organization.

DISTRIBUTION ENGINEERS are as much concerned with quality control as are their colleagues in Western Electric's manufacturing organization. In the repair shop, as in the factory, strict tests guarantee the quality and uniformity of products, new or renewed. To insure uniformity of inspection standards throughout the distributing chain, quality control engineers from the headquarters staff make the rounds of the repair shops, conducting independent inspections of their own. The results of these survey inspections are matched against the local inspection results obtained by the repair shop organizations themselves, so that the same high standards of quality control may apply in every distributing house. Undesirable conditions detected in one repair shop can be corrected before the same conditions appear elsewhere. Curative measures found successful in one area can be made available to all others simultaneously.

Bell System standard practices govern the inspection procedures observed by the distributing houses. Issued by the Bell Telephone Laboratories, these practices incorporate the expressed requirements of the operating telephone companies. Thus, in the final analysis, the telephone companies themselves establish the standards for the Western Electric repair shops which serve them. The system of centralized survey inspections, conducted under common management of all the distributing houses, is double guarantee that these standards, so important to the country's telephone service, are scrupulously maintained.

And through the efforts of the headquarters engineering group, the efficiency and economy of operations at each individual distributing house are constantly improved through the common experience of all. The advantages of Western Electric's nation-wide training and experience which accrue to each telephone company must be obvious.

LEST too much emphasis seem to be placed on common management and centralized control, let it be said now that the success of each distributing house depends on the degree to which it serves the needs of the local telephone company. The efficiencies and economies to be derived from centralization are matched by the efficiences and economies which derive from the close day-to-day working relationship between the distributing house and the telephone company it serves. It is this relationship—and the cumulative experience of this relationship—that translates telephone company needs into Western Electric deeds.

It is a long way from the factory to the front line of telephone service.* Yet in the distributing house it is sometimes difficult to tell where Western Electric leaves off and telephone company begins. For the distributing houses are bridges, linking the supply unit of the Bell System with the operating units of the System. Over these bridges pass the vast quantities of materials that help make telephone service.

* See "Final Steps in Supply Distribution," QUARTERLY, October 1940.

How Big Are the Little Things In the Telephone Business?

Keith S. McHugh

Editors' note: This is the text of a talk given at the Bell System public relations conference last June by the A. T. & T. Vice President in charge of public relations.

NOT LONG AGO I made a talk about some aspects of our business before a group of men, most of whom are presidents or officers of their companies. During the talk I had occasion to refer to the size of the Bell System in terms of plant investment and number of employees.

After the talk was concluded, a number of the men continued the discussion, and one, who manages a large business, said "I think the telephone company has done the finest management job in business. It is a great institution. But I am sorry to say that I don't see how you can possibly hold that place, because you are getting too big. No business as big as yours can possibly be efficient." Some of the others present clearly agreed with him.

I did my best to convince them that we are fully aware of this danger. I pointed out that we continuously carry on research; we have developed a highly competitive system for all supervisory personnel within our business; and we practice real decentralization of authority and responsibility. But I doubt if they were fully convinced that these measures, as good as they might be, were enough.

There are different ways of characterizing the elements of a successful business, but we may confidently assert that somehow the following elements must be present:

1. *A good product or service sold at prices which are so attractive that customers will spend their money for it and come back for more.*
2. *Investors who are impressed sufficiently with the record and prospects of the business to risk their savings.*
3. *A management which can produce adequate earnings over the long pull.*
4. *Employees who are well paid, enjoy good working conditions, feel secure in their jobs and, in the main, sincerely believe (and willingly tell their friends) that the company is a good employer.*
5. *A forward-looking policy of research and development to keep abreast of or ahead of the competition for the customer's dollar.*
6. *A way of doing business which earns a general reputation as a good citizen.*

There may be other elements which you think should be added to the list. And their number, and the emphasis placed on each, changes with the times. Many years ago only the first three—a product which would sell, a willing entrepreneur, and good earnings—were considered by many business men in America as all that was required for the success formula. Emphasis

on fair treatment of employees, on research and development, and on good citizenship is generally of fairly recent vintage.

I think we may fairly say that the telephone companies—perhaps because of the unusual characteristics of their business—early gave more attention to these last three points than did many other businesses which did not have to be particularly concerned about State and Federal regulation and scrutiny, which were satisfied to do a minimum of product research or design, and which were unimpressed with the idea that they had to be good citizens in the communities in which they had plants or sold their products. But today, almost all large businesses are aware of these requirements; and the telephone companies, instead of being the leaders in practicing these virtues, now have lots of company in the front rank.

TODAY I would like to discuss some phases of the first requirement, good service, and of the last, good citizenship, with particular reference to the question raised earlier, namely, "Are we becoming so big that we can't possibly be efficient?"

The dictionary defines the word "efficient" as "highly capable or productive, or effective in operation." Let me point out that this definition covers a lot more territory than the behavior of a dial switch, the layout of a cable network, or the filing of customers' records in a business office. It also tells us that real efficiency in our business depends on people doing all the things—including the little things—that may be, as the dictionary says, highly "effective in operation."

On what do other people base their ideas of the efficiency of the telephone company? It seems to me that their ideas come from their reaction to that part of the company's operations which touches them most as individuals. Thus, a stockholder interested primarily in his telephone investment no doubt judges our efficiency in terms of reliability of earnings and dividends and in the value which others place on his investment. Bankers, insurance companies, investment counsel, financial writers—all might make these results the first test of efficiency.

USERS OF OUR SERVICE think we are efficient when we get their calls through promptly; we are inefficient when the calls are delayed. When a toll operator goes to some unusual trouble in locating the called person or performs some special service in an emergency, the recipient of this service not only thinks we are efficient, but is apt to talk about it to others. When a user gets a bill that is in error, but receives courteous treatment of his complaint by the business office representative and prompt correction, he may think we are efficient despite the error; but continued errors or bad handling of a single error make him think us inefficient. If his telephone goes out of order and we have a man out at his home promptly to fix it—and especially if we find the trouble first, and repair it before he report it—we are very efficient. But if we are slow, or the telephone stays in trouble after repair, he thinks we are inefficient.

The people who make up the public are citizens as well as telephone users, and think of us from both points of view. As citizens, they drive through city streets and over country roads and see our crews at work; they think we are efficient or not efficient based on what they see these crews doing. They form their judgments when we make pole placements, trim trees, construct buildings, open the streets to place cable; in fact, when enaged in any of the multitude of operations which are necessary to our business. These offend if done carelessly or thoughtlessly; they please, or perhaps fail to offend, if done well.

THE CITIZEN forms judgments of our operations in other ways. Do telephone people as citizens or as representatives of the company participate actively in worthwhile community affairs? Does the company contribute to worth-while community

enterprises—prodigally—fairly—in a miserly way—or not at all?

Do telephone men and women take so whole-hearted and genuine an interest in the community that it never occurs to other citizens to question their enthusiasm and freedom to act on community problems? Do most decisions of the company, of importance to the community or its citizens, wait interminably while impotent local management checks headquarters? Are telephone rate practices and commercial policies designed in the best interests of the community, and are they watched and changed to keep them that way as conditions change?

These questions illuminate a simple truth, but a truth of great and continuing consequence to the success of the business: *In the long run, people's ideas of our efficiency are determined largely by the* little *things we do or fail to do.*

I am assuming, of course, a fundamentally good technical service job and sound general policies. Beyond these, the fact and quality of the "overtones of service" and of what we might label correspondingly the "overtones of corporate acts" are the things by which people judge us. The little extra courtesies of the commercial representative, the installer, the repairman, the operator; the character of personal interviews with customers whether rich or poor, prominent or unknown, to explain errors or service difficulties or perhaps the inability to give any service; the knowledge of the company and its policies displayed by employees in making explanations of matters outside their special skills and their belief in the company; the manner in which we deal with city, county, or state governments; the care we take with the property of others—their trees, their view, their streets and highways; these are what I call the "little things."

THESE LITTLE THINGS give the public and telephone users the bases for measuring our efficiency. And they do more than that if done well—they make our character and give us our reputation. They make a joy of the job to each of those who do them. There is so much more fun doing a job which is pleasing to other people than in doing one which is not.

If we can manage it so that our own people, or nearly all of them, get a kick out of their jobs by doing these little things thoughtfully and well, we need have no fear that the people of America will say anything other than "We think the telephone companies are all right. They are good employers, have good people, and are good citizens." We need not be concerned about the size of this business, whether or not the Bell System's plant investment goes to ten billions of dollars or the total of employees goes to a million. Our companies' fundamental standing will have been made in the communities of America where it must be made, and home-town folks will take pride in their home-town telephone friends and neighbors and in their home-town telephone company.

And manage this we must. As our companies increase in size, in distance from top to bottom, and in difficulty of implementing ideas, we in management must work unceasingly to hold our gains in the doing of the little things and in improving their doing. This is the fact which all telephone management must face and to which we in public relations must make a maximum continuing contribution.

Natural or Synthetic, They Are the Product of Chemical Science, Possessing Properties Which Fit Them Well for Important Communication Functions

Plastics—Their Growing Use in Telephone Plant

John R. Townsend

THE FIRST telephone receivers to be produced in any quantity, after wooden casings were abandoned 'way back in 1877, were made of plastic material.

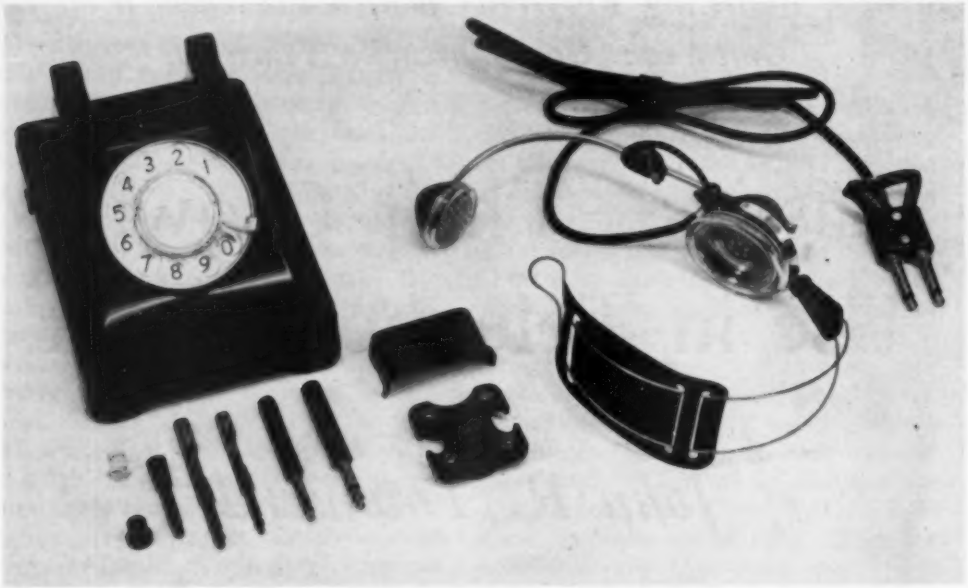
So are the operators' light-weight head sets adopted in the Bell System in 1946.

The old telephone receivers were created out of hard rubber: "hard" because Goodyear's discovery of how to vulcanize the soft latex from the trees made it possible to mold and harden *natural* rubber. The new light head sets are formed out of phenol plastic: *synthetic* (artificial) material which also can be given useful shape through the application of heat and pressure.

These are but two examples, out of many, of the Bell System's adoption and adaptation of materials and processes to special uses in the communications field. As natural materials become scarce, and as new types of synthetics are developed, plastics are playing an increasingly important part in the manufacture of many elements of telephone plant.

Lead, for example, has been the major component of telephone cable sheath since copper wires were first successfully enclosed in its protective embrace. In recent years, lead has been in scarce supply.

Are we about to produce lead synthetically then? No indeed. But what we are doing is developing combinations of synthetic materials which may turn out to do as good a job of protection as lead did, and may therefore be an alternative and a supplement to lead. Specifically, the excellent water-resisting properties of polyethylene and rubber thermoplastic give promise that, when combined in "sandwich" construction with metal tapes or thin metal sheaths, these materials will provide a workable substitute for lead cable sheath.



The adaptability of plastics is illustrated by this variety of plastic products, including the combined set housing and finger wheel; the operator head set with plastic caps on transmitter and receiver; and key buttons, plug insulation, and connector block and cover

Textile insulation for wire has also been hard to obtain in sufficient quantity, and the possibilities of using plastics here are being studied. Extruded plastic coatings on copper and aluminum wire may become of great importance in the telephone business. Drop wire jacketed with neoprene; switchboard cable jacketed with polyvinyl chloride; switchboard wire insulated with polyvinyl chloride and polyethylene; neoprene and nylon for sheathing: all these are on trial.

A rapidly growing field of use is that of the new adhesives, which are compounded of various plastics. These adhesives are very strong, permanent, water-resistant, and unaffected by fungi. They may be applied successfully to join many materials: other plastics, wood, ceramics, even metals. It is these qualities which make possible the creation of composite or "sandwich" products combining properties no single material can possess. Think of them in terms of the prefabrication of many things used in the telephone business: from movable central office partitions to portable equipment, from telephone booths to cabinets for the micro-wave repeater project. Those are, of course, for the future.

A Future—and a Past

NEW USES, new applications of plastics are developing day by day. It is a lively and growing industry. But it is by no means all new: plastics have a past as well as a future. Actually, much telephone apparatus of one sort and another—some of it entirely familiar—has long been made of plastic material. The hand tele-

phone is one example; the combined-set housing is already becoming another. From plastic materials are made dial finger-wheels, connector blocks, key button tops, plugs, vacuum-tube bases, protector mountings, and insulators of various kinds.

A plastic may be any one of a great number of materials and of both natural and synthetic origin. For example, phenol plastic, rubber, shellac, methyl methacrylate, are all plastics. Rubbers may be either natural or synthetic, shellac is natural, and phenol plastic is synthetic. Plastics are very often combined with other materials as fillers. They may be used as paints and adhesives.

The common denominator of all plastics is that at some time in their career they must be capable of being cast, extruded, pressed, formed, after which they cool or age to comprise a usable part. The flowing or plastic deformation may be carried out by heat, by pressure, or both. Some plastics are fluid to begin with and are cured or changed to a harder substance. When this happens, solidification or polymerization, or both, may take place. The former means the combination of two or more molecules with the liberation of water, hydrogen chloride, or other material, to form a new substance. Polymerization is a chemical process resulting in the formation of a new compound whose molecular weight is a multiple of that of the original substance.

For convenience, plastics may be

Combined-set bases travel by conveyor to the next process after being removed from the injection molding machine

Vacuum tubes with plastic bases are placed in aging racks, where they are stabilized and tested

divided between thermoplastic and thermosetting materials. The former comprise those substances that can be re-softened by heat. The latter cannot be re-softened because a non-reversible chemical change has taken place. Cellulose acetate, methyl methacrylate, are examples of the former; phenol formaldehyde and urea formaldehyde are examples of the latter.

Compounds and Qualities

THE COMPOUNDING of a plastic is a highly skilled art. Fillers are added to provide bulk, strength, and electrical characteristics. Plasticizers are added to increase flow and workability. Pigments and reenforcing materials also form a part of the compound. Thousands of compounds are thus available for use.

Plastics as used in the Bell System may be grouped in three classes, each characterized by particular qualities.

One is for applications requiring mechanical strength: the ability to hold to original shape and size, and to stand up under impact, wear, battering and bending and stretching.

Another is for electrical applications where insulation and arc resistance and non-conductivity are important.

Still a third class is for general application where an economical part of pleasing appearance and reasonable strength and perfomance is desired.

These are the broad bases on which a particular plastic may be selected for a particular use or service. Any or all of these desirable qualities may be useful in practical application.

The earliest plastics in the telephone plant were insulating materials such as hard rubber, vulcanized fibre, and shellac-mica compositions. Among the first synthetic plastics was Bakelite, which came to be used in molded form and as the resin in phenol fibre.

Phenol plastic forms an insulat-

ing material used mainly where stability combined with reasonable strength is important. It is used for our telephone hand set. This particular compound consists of phenol formaldehyde resin with 50 percent filler, the latter being a mixture of wood flour or ground wood and cotton floc or linters. It is cheap, strong, mechanically stable, and chemically inert. As a rule, and this is true of most plastics, the parts come from the molding die substantially ready for use with excellent surface finish.

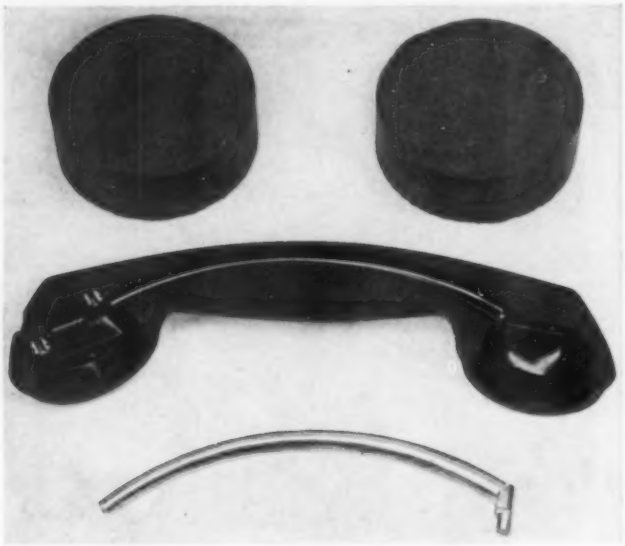
Akin to phenol plastic is phenol fibre. This is made by impregnating various types of absorbent paper with phenol formaldehyde laminating varnishes. After drying or partially curing the resins, the sheets of varnish-impregnated paper are stacked in a press and cured under a pressure of one-half to one ton per square inch at a temperature of approximately 325°F. for about one hour.

A new operator head set, with plastic caps on transmitter and receiver, gets a "talk test"

Plastics as Insulators

VARIOUS GRADES or kinds of phenol fibre are used. These vary in resin content and formulation and in the character of the surface sheet. High resin content produces good electrical characteristics; lower resin content, good mechanical strength; and for certain grades a tung oil plasticized varnish is used. Instead of paper, cloth may be employed to obtain variations in strength and appearance.

Organic plastics do not conduct electricity, and hence form insulators. These insulators must be very good, so that the telephone's comparatively feeble electric currents will not leak away or be lost in transmission. Telephone apparatus must also be stable, so that the adjustment of relays, keys, switches will be reasonably permanent. Insulators must not deteriorate chemically or affect adjacent parts nor cause corrosion or deterioration. Consequently, the properties of mechanical and chemi-



Out of these components will come a hand telephone. Top to bottom: plastic pre-forms, half section of molded handle, and core

cal stability are of predominant importance in the telephone art.

Plastic parts that are placed in the hands of the public—hand sets, for example—must not only be good insulators, but must be chemically stable and not affect the subscriber's person. Appearance, fire hazard, physical strength, and manufacturing facility are properties of considerable importance. Other qualities are, for instance, specific gravity, tensile strength, electrical characteristics, and availability.

Plastics vary greatly in price and in processing costs. The selection of the most suitable plastic for a given application is thus a complicated engineering problem.

Plastics have brought in their train several difficulties which must be dealt with in apparatus design. Age cracking or crazing can occur with some plastics in ordinary atmospheres, when flexed or strained, or in contact with solvents. The latter factor is particularly important when certain household cleaners are used.

Fastness to light, and particularly light and humidity, is a problem. This is of major importance with colored objects where a pleasing appearance is desired. Exposure tests have been carried on for years on the roof of the Bell Telephone Laboratories in New York. Tests have also been made at various locations throughout the United States:—Miami, Key West, Pittsburgh, Sandy Hook, and in the Panama Canal Zone. Thousands of specimens have been exposed and tested in natural as well as artificial environments. These have been specific telephone parts, combinations of parts, test panels, corrosion couples, etc. As new plastics appear, more tests are made. Fatigue tests by reversed flexing or by repeated impact are of great importance for dynamic uses.

New Manufacturing Arts

THE GROWING USE of plastic for telephone parts—the hand set, the operator's head set, the housing for the combined set, to mention only a few—has required the development of new manufacturing arts on the part of the Western Electric Company—the supply branch of the Bell System.

For many years, the insulation used on telephone plugs—the insulated metal end-piece attached to a connecting cord—was of hard rubber. Not infrequently, during the assembling process, metal chips would be picked up which would short-circuit the insulation. The injection molding of plastic material for insulation of the plug parts eliminated this difficulty and produced a plug with better and more stable insulation.

Originally, the connecting wires between transmitter and receiver of the hand set telephone were inserted in the mold before heating. As a consequence, it was hard to keep the wires apart during the operation, to avoid a subsequent short-circuit; and the plastic material at the center of the handle was not always fully cured. Now, the use of a metal core, which is a Western Electric development, not only keeps the wires separate, but permits the molding of a dense and very strong handle.

This can be brought about because, as a general rule, materials which are good insulators, and hence poor conductors of electricity, are also indifferent conductors of heat—since these properties tend to go hand

The hot pre-forms are dropped into the dies, the press closes, and in three minutes seven new hand telephones emerge

in hand. It has been difficult to cure heavy sections of phenol plastic because of this quality of poor heat conductivity, and thus the center of the hand set was not fully cured. A development just before the war demonstrated that the center of thick moldings could be "cooked" by the use of high-frequency electrical heating:—diathermy if you please.

For the hand set, specially compressed pellets of dry molding powder are placed betwen two plates in the output of a 14-megacycle 7-kilowatt oscillator for half a minute. This heats the pellets through by dielectric loss: the dissipation of the energy induced in them. The pellets come from the heating apparatus in a soft state, and may be quickly formed by pressure to the desired shape. This "curing" reduces the total process time, and produces a hand set of superior strength.

ANOTHER PROCESS that has become of great practical importance is that of casting resin. The resin is placed in a mold in liquid form, and is caused chemically to react by the addition of a catalyst to become a hard and infusible substance. During the war, casting resins of this type were used to make porous metal castings water and air-tight. This is possible because of their very low shrinkage.

Following the war, it was found possible to cast terminal strips in simple molds into which the terminals are inserted and the mold is filled with the casting resin compound. The particular resin used is a mixture of polystyrene monomer and a polyester plus a catalyst. In order to economize in the use of the plastic material, and also to reduce shrinkage and improve the stability of the casting, about 40 percent silica is added to the resins. Spun glass floc is also added to improve strength and some titanium dioxide to color the casting white. This is another example in pioneering by the Western Electric in a new field.

Western Electric also pioneered in the injection molding of so complicated an object as the combined telephone set.

A New Science

PLASTICS are competitive with other materials and processes, such as welding, casting, sheet metal fabrication. Good engineering must start from service needs and proceed to the selection of the best material and process from the standpoint of basic costs and adequate life. Plastics will replace some of our older materials because they will be better, and there will be instances where the molding process will provide economy over other processes in spite of higher cost of material.

Synthetic plastics are a product of modern chemical science and have no counterpart in natural materials. Practically all of these plastics are new. A large majority of them have come into commercial use since 1930, and some of the most valuable plastics from a communication standpoint, such as polyvinyl chloride and polyethylene, have been available only since 1938 and 1941, respectively. We do not have, therefore, the background of solid experience and familiarity of a great variety of service conditions with these new plastics that we have with natural and the older synthetic plastics—such as Bakelite, which appeared in 1909,

and cellulose nitrate, which appeared in 1868. Any prospective use of these new plastics requires intensive laboratory and field trials and compilation of experience data from service.

Bell Laboratories' Part

AT BELL TELEPHONE LABORATORIES, a division of the Chemical Department is indeed devoting itself to development and engineering studies of plastics. This group is primarily concerned with the application of plastics in the design of telephone apparatus, and one of its functions is to bring about developments in the plastics industry which can be used to advantage by the Bell System. Research efforts in this group have led also to the development of interesting new plastics, among which is Paracon, a synthetic rubber having valuable properties.

Plastics are not yet available for all of our needs, nor are they a panacea for all of our difficulties. But it is to be expected that their use will increase with developments in modern chemistry.

Automotive Authority

At about the time that Temple C. Smith's "Keeping Our Automotive Equipment Modern" appeared in the last (Summer) issue of this MAGAZINE, a shorter version of it, described as a "guest editorial," was published in *Fleet Owner,* a trade journal of the truck industry. Our readers may be interested in that publication's estimate of Mr. Smith and his job:

"It is fitting that Mr. Smith should be invited to be a Guest Editor. His position with the telephone system brings distinction, as this organization operates one of the largest fleets in the country. Mr. Smith also speaks with authority, based on a good technical education as the foundation for many years of practical application of engineering principles to automotive requirements.

"It is fitting also that Mr. Smith selected a subject that points to what ultimately may become the predominate post-war trend—that of engineering the vehicle to the job. His company has had much experience in this direction, for the telephone fleet is called on to perform many jobs.

"Most of us may think of the telephone truck as a piece of equipment that stops in front of our home from time to time, while the repairman inspects the instrument or strings a new line of wire from the house to the nearest pole.

"The telephone company's fleet has many other tasks to perform, involving hauling and supplying of power.

"The engineering involved in producing the right equipment must have presented Mr. Smith with many interesting problems. Out of this vast experience has come some guide posts, and these should prove of great value to other operators in rebuilding and adding to these post-war fleets."

Excursion in Engineering

Carroll O. Bickelhaupt

Editors' note: At the commencement exercises of the South Dakota School of Mines and Technology, held at Rapid City last June, Mr. Bickelhaupt, who is Vice President and Secretary of the A. T. & T. Co., received the honorary degree of Doctor of Engineering. The following paragraphs are excerpts from the commencement address which he delivered.

UNTIL COMPARATIVELY RECENT TIMES, the social effectiveness of the engineer was largely indirect or undirected. As new vistas of scientific knowledge were opened up, he went ahead with the job of applying these discoveries to the finite satisfaction of human needs. The scope of his endeavor, however, has been circumscribed by the incentives of his professional environment and he has confined his work mainly to the objectives of industrial enterprise. Meanwhile, he has left to those in the field of politics the control of the social implications of his output.

But the engineer had done such a good job in providing the tools and processes of production, and had done so much to make life better, happier, and freer, that when his work began to react perceptibly upon our social pattern, the rule makers of government began to look to him for help in meeting the problems of human relations with which our social, economic, and political system is confronted. Thus, whether, as engineers, we planned it that way or not, and whether we like it or not, we have, I believe, arrived at a point in our professional progress where we must take an increasingly active part in social research and social planning and social orientation.

The problems of human relations are broad and complex. Like many physical problems, they have not been and quite likely can't be solved by individuals. It is difficult to believe that any one brain can even comprehend, much less analyze and evaluate, the delicately interlaced fabric of human desires, impulses, behaviorism, and its complex of interreactions. But there is basis for hope that one by one these intricate problems, the solution of which is so important to us all, may yield to coöperative research.

This is a method in which scientists and engineers are well versed. The scientific approach has been applied successfully to the solution of many material problems. It is deliberate but thorough. There is no place in it for the prejudice, bias, subjectivity, and wishful thinking which have been so evident in our dealings with human affairs and relations, particularly during recent years.

I have the notion that many of the social or human problems we worry about and that trouble us from time to time are in the nature of transient phenomena. Like sudden but temporary surges of current in electrical transmission lines, they sharply upset the pattern of our social environment, do violence to our sense of security, and shake the confidence we have in our ability to pursue the good life. Steinmetz, in his classic volume, "Theory and Calculations of Transient Electric Phenomena and Oscil-

lations"—a book which, as an undergraduate, I found even more formidable than its title—disclosed the pattern of these violent but temporary electrical surges, formalized man's experience with them, and developed the mathematics for predicting their nature, energy, and duration. I have no doubt that some of you here today will cooperate in similarly opening up new fields of knowledge with respect to transient social forces.

In any event, you will find yourselves more and more required to extend your work and thinking beyond the limits of material science and its applications, and you will find yourselves more and more concerned with the social implications of your output. As you advance in your profession, do not make the mistake that has been made so often in the past. Do not forget that man's progress in the pursuit of happiness cannot be hastened by expedients or by "first aid" treatment, and that it will come not through regimentation by the few but by the long-range processes of individual liberty.

I purposely use the good old engineering term "long range," because mankind forges slowly but surely ahead as more and more people are freed to think for themselves, to take on more and more responsibility, and as the individual is increasingly dignified and respected for what he is and can make of himself. On the other hand, as his individual freedom is circumscribed, man tends to retrograde.

I think you, as engineers, will have to concern yourselves in your work, more than my generation has, with secular trends in social forces. Many of you will play an important and vital part in business. You will provide the tools of industry and be looked to for much of its planning. You must see to it that your work is socially oriented. You must take the long-range view. You must apply the proven procedures of scientific approach and coöperative research to the human problems of industry and society. Above all, you must continuously defend the freedom of the individual. How well you do this will be a measure of your professional progress.

TOWARDS THE LATTER PART of World War II, when the Allied armies in Europe were pushing the Germans back across their own frontiers, and military, naval, and air activities in the Pacific were building up in the crescendo which defeated the Jap, a friend of mine who was Chief of our Army Communications Service became impressed, and not a little concerned, about the volume of traffic the American military communications system was transmitting around the world by wire, submarine cables, and radio between and within the respective theaters of operation. Upon adding up the volumes of command and administrative traffic the Army Communications Service was handling by telegraph only, he found that for every small-arms and machine-gun bullet fired by the American ground and air forces, eight words were being transmitted by the Army Communications Service. He concluded then, he says, that "the pen is mightier than the sword."

Whether or not you agree with this conclusion, you may be sure that words are going to play a most important part in your working and professional life. They are the tools of your trade; the "vehicles of ideas." You must learn to use them and to make them work for you. To the extent to which you are able to do this, your professional path will be smoothed and your progress accelerated. I venture to say that for many of you this is going to be one of the hardest, yet quite probably one of the most important things you will have to do in the next few years after graduation.

I have already referred to Leonardo da Vinci as an engineer whose engineering achievements are little known and are overshadowed by his fame as an artist. Unfortunately, as Vallentin points out, "his unique career, a lifetime devoted to research in every field of human knowledge, ended without the publication even of fragments

of his conclusions. Mankind was to have to discover afresh the paths he had trodden and mapped, to fall into his errors after he had recognized them, to struggle out of the traps he had evaded."

Then too, we heard a good deal, not so many years ago, about the men who were so urgently needed and essential to the Washington scene: men whose qualifications, it was said, "must include a passion for anonymity." My impression is that I have read more about these men in the public press and heard more about them on the radio than I have ever heard or read about the great engineers who have done so much, among other things, to bring newspapers and radio broadcasting into the daily life of the nation.

Francis Bacon said, "I hold every man a debtor to his profession." If the engineer is to pay the debt he owes his calling, he must become articulate. He must acquire and practice the persuasive arts. If he is to occupy the place in our society which is rightfully his by accomplishment, he must tear aside the veil of anonymity with which his vocation has been shrouded since its beginnings.

And so I say again, words are important to you. I urge you to learn to apply them to your professional ends. They are the media of communication, and communication is the basis of coöperative effort.

THE PROFESSION you have chosen is not an easy one to follow. Its pursuit is arduous but its rewards are great. It holds out the romance of the untraveled trail and rewards its followers with the satisfactions that come from finite creation. Do not be dismayed if you meet with disappointment. Yours is an honored profession. You have a great and useful place to fill. You have taken the first long step towards your goal, and the fact that you are here today denotes that you have done it well.

Some of you, I suspect, have served in the Navy. Those of you who have, and those who have followed naval history, know that the highest praise a naval commander can give is summed up in the terse and simple signal, "Well done!" That signal should be made at every convocation where the graduation of engineering cadets is celebrated. It may well be supplemented, also, by that forceful message of hope and faith I have heard the great War Prime Minister of England, Winston Churchill, thunder out in his country's dark hour; that one-word fighting message, "Dreadnaught."

When he invited me to talk with you at this convocation, your president graciously indicated I might address myself to any subject I wanted to talk about. He went on to suggest, however, that I refrain from "preaching." He didn't use exactly those words, but his meaning was entirely apparent to me even if delicately expressed. Taking him at his word, we have strolled in and about the engineering scene today much as sightseers. If you have acquired any impressions of its human climate, our excursion has served its purpose. But if I should be accused of preaching to you, let me at least make sure I am not charged with preaching without a text, even though I conclude with it rather than begin from it as is the classic manner.

Let me mark the end of our excursion by quoting to you from Robert Louis Stevenson, not because what he has said in this passage bears implicitly upon what I have tried to say today, but because it is something for each of us to remember, particularly when the horizon is dark about us and our world is troubled, and especially because it is the specification of our most important individual job:

"To be honest, to be kind—to earn a little and spend a little less, to make upon the whole a family happier for his presence, to renounce when that shall be necessary and not to be embittered, to keep a few friends, but these without capitulation—above all, on the same grim conditions, to keep friends with himself—here is a task for all that a man has of fortitude and delicacy."

Post-war Information from Official Sources throughout the World Permits Compilation of Up-to-date Communication Statistics for Most Countries

Telephones in the World Of 1947

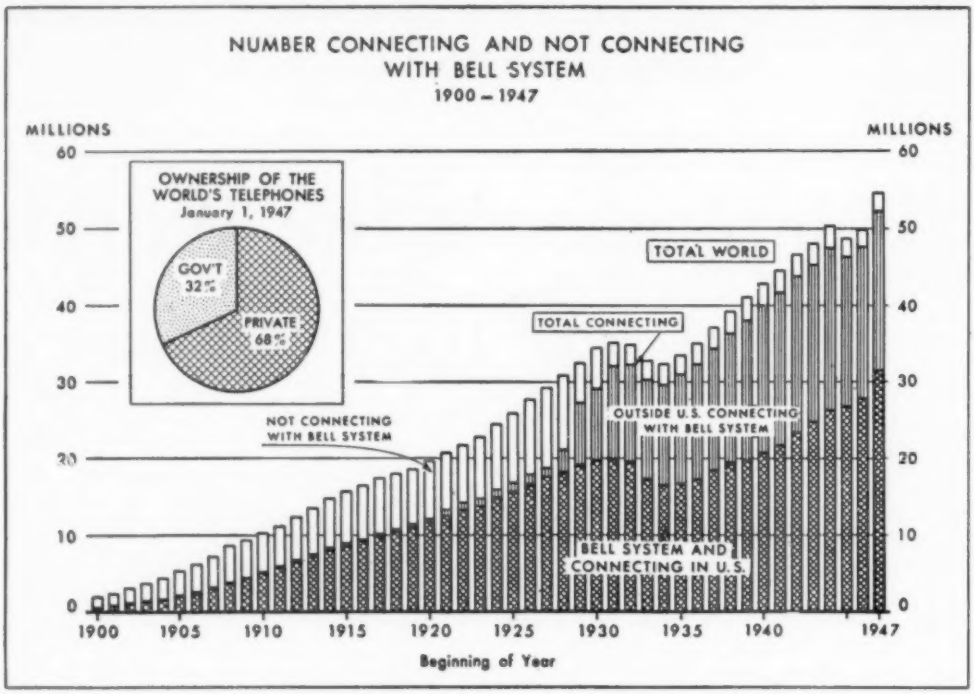
James R. McGowan

IN 1876 there were two telephones in a world of 1.35 billion people. "The most wonderful thing in America," was how Lord Kelvin described Alexander Graham Bell's telephones, which were then being exhibited at the Philadelphia Centennial Exposition in June of 1876. On January 1, 1947, in a world of 2.35 billion people, there were 54.6 million "wonderful things."

A compilation showing the status of world telephone development, by countries, as of January 1, 1947, the twenty-seventh issue of *Telephone Statistics of the World,* was issued recently by the Chief Statistician of the American Telephone and Telegraph Company. This bulletin, based upon information obtained directly from private and governmental communications administrations throughout the world, has appeared annually since 1912, with the exception of those periods during World Wars I and II when telecommunications data on a world-wide basis were not available. Although the current edition is broader in scope than that of the preceding year, telephone statistics for some of the war-torn countries, notably Germany, are still lacking, while statistical data pertaining to the communications facilities of other nations, such as Italy, the U.S.S.R., and Yugoslavia, are incomplete. However, allowance has been made for these factors in estimating the continental totals shown in the bulletin from which the accompanying charts and tables are reprinted.

The First Million Telephones

THE YEAR 1899, twenty-four years after Mr. Bell had successfully demonstrated his telephone theory by experiment, saw the United States attain its millionth telephone, while all the rest of the world had arrived at a total slightly less than that. Since



the beginning of this century, the ideal of universal telephone service has assumed greater and greater significance. Through continuous and vigorous research in the telephone art, the Bell System over the years has made many outstanding contributions to a service which today places 96 percent of the world's telephones potentially within the reach of any Bell System subscriber.

The Telephone in America

MORE THAN seven billion dollars' worth of telephones, switching equipment, wire, cable, buildings, vehicles, and other physical plant stand behind the largest communications system of the world, that of the United States. Under the stewardship of private enterprise since its inception, the telephone system in this country has always maintained world supremacy both in absolute size and in telephone density (i.e., number of telephones in relation to population). At the beginning of 1947, a development of 22.37 telephones per 100 population was attained, or a telephone density almost ten times that for the world as a whole. This development has been attained despite the fact that the telephone companies in this country have unfilled orders for more than two million new telephones which are waiting chiefly for the manufacture and installation of additional switching equipment and other needed plant facilities. However, during the year 1946 the Bell System alone, which operates 80 percent of the nation's telephones, added 3,264,000 new telephones to its network—a number equal to four-fifths of all the telephones serving the United Kingdom, the second largest

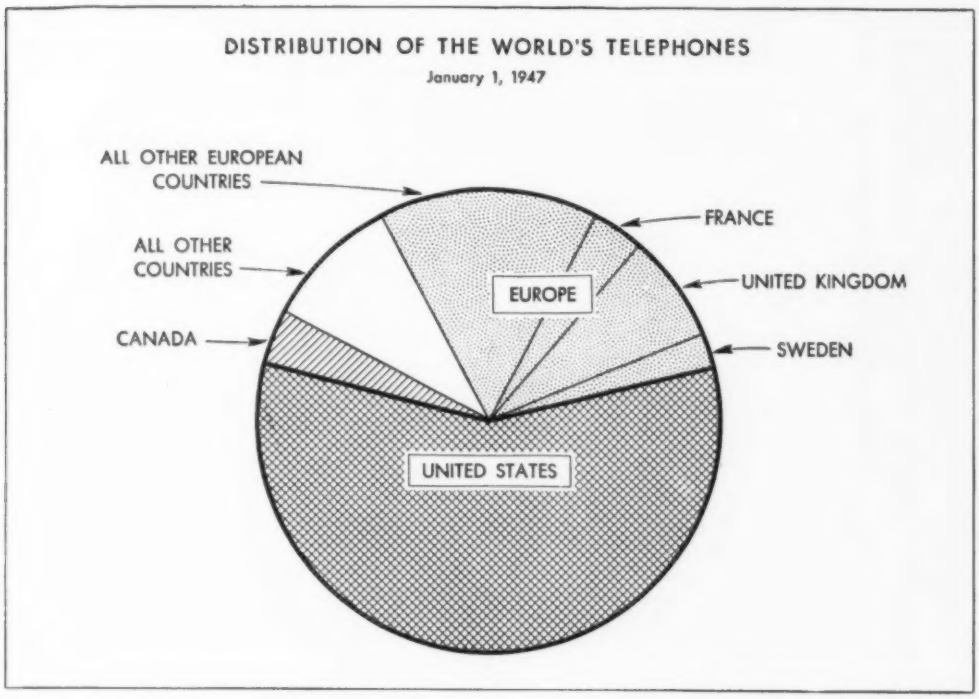
communications system in the world.

Among the 31,611,000 telephones serving the United States on January 1, 1947, the "dial tone" could be heard over no less than 18,700,000, which represent 58 percent of the dial-operated instruments estimated for the world. The telephones of America are interconnected by more than 116 million miles of wire, three-fifths of it underground and 95 percent of it in cables, and they can be

THE WORLD'S TELEPHONES BY CONTINENTAL AREAS
January 1, 1947 [1]

Areas	Government Systems	Private Companies	Total	Distribution	Per 100 Population	Automatic (or Dial)	
						Number (Included in Total)	Per Cent of Total Telephones
North America (less United States)	332,000	2,148,000	2,480,000	4.54%	3.98	1,422,000	57.34%
United States	—	31,611,000	31,611,000	57.90%	22.37	18,700,000	59.16%
South America	658,000	720,000	1,378,000	2.52%	1.36	963,000	69.88%
Europe	13,470,000	2,280,000	15,750,000	28.85%	2.65	9,600,000	60.95%
Asia	1,360,000	181,000	1,541,000	2.82%	0.13	590,000	38.29%
Africa	583,000	7,000	590,000	1.08%	0.32	380,000	64.41%
Oceania	1,166,000	84,000	1,250,000	2.29%	1.23	745,000	59.60%
World	17,569,000	37,031,000	54,600,000	100.00%	2.32	32,400,000	59.34%

[1] Partly estimated, all data having been adjusted to January 1, 1947 basis.



TELEPHONE DEVELOPMENT OF THE WORLD, BY COUNTRIES, JANUARY 1, 1947

Countries	Number of Telephones				Automatic (or Dial)	
	Government Systems	Private Companies	Total	Per 100 Population	Number (included in Total)	Per Cent of Total Telephones
NORTH AMERICA:						
United States	—	31,611,000	31,611,000	22.37	18,700,000	59.16%
Canada	283,300	1,740,400	2,023,700	16.32	1,133,300	56.00%
Central America	30,700	22,300	53,000	0.55	19,000	35.85%
Mexico	3,000	222,000	225,000	0.98	154,822	68.81%
West Indies:						
Cuba	530	85,270	85,800	1.69	71 836	83.72%
Puerto Rico	1,022	27,043	28,065	1.31	13,880	49.46%
Trinidad and Tobago	145	10,442	10,587	1.88	6,792	64.15%
Other Places in the West Indies	13,300	16,100	29,400	0.33	22,040	74.97%
Other Places in North America	200	24,300	24,500	5.16	330	1.35%
SOUTH AMERICA:						
Argentina	540,000	50,000	590,000	4.05	430,000	72.88%
Bolivia	—	7,700	7,700	0.20	5,000	64.94%
Brazil	1,500	438,000	439,500	0.93	313,300	71.29%
Chile	—	113,200	113,200	2.07	75,007	66.26%
Colombia	34,100	21,600	55,700	0.54	16,000	28.73%
Ecuador	4,600	5,200	9,800	0.29	1,000	10.20%
Paraguay	4,400	—	4,400	0.37	3,700	84.09%
Peru	—	41,000	41,000	0.52	30,415	74.18%
Uruguay	68,400	1,600	70,000	3.02	51,051	72.93%
Venezuela	800	41,700	42,500	0.96	37,400	88.00%
Other Places in South America	4,200	—	4,200	0.68	133	3.17%
EUROPE:						
Austria	275,139	—	275,139	3.93	202,013	73.42%
Belgium	450,259	—	450,259	5.37	323,471	71.84%
Bulgaria	52,765	—	52,765	0.75	22,000	41.69%
Czechoslovakia	311,810	—	311,810	2.60	165,000	52.92%
Denmark	27,784 [4]	563,961	591,745	14.33	196,500	33.21%
Eire	57,174	—	57,174	1.94	32,808	57.38%

Finland	25,517	238,714	264,231	6.78	141,655	53.61%
France	1,997,335	—	1,997,335	4.93	1,321,089	66.14%
Greece [4]	1,000	57,700	58,700	0.78	57,700	98.30%
Hungary	79,010	—	79,010	0.82	55,047	69.67%
Netherlands	514,355	—	514,355	5.41	448,625	87.22%
Norway [1]	237,579	95,891	333,470	10.94	185,460	55.62%
Poland	169,821	—	169,821	0.70	110,000	64.77%
Portugal	32,284 *	72,185	104,469	1.26	43,588	41.72%
Romania	1,022	126,131	127,153	0.76	96,402	75.82%
Spain	—	477,866	477,866	1.75	333,751	69.84%
Sweden [2]	1,242,071	2,002	1,244,073	18.64	701.940	56.42%
Switzerland	697,589	—	697,589	15.57	635,000	91.03%
U.S.S.R. †	1,500,000	—	1,500,000	0.71	400,000	26.67%
United Kingdom [3]	3,976,936	—	3,976,936	8.43	2,639,204	66.36%
Other Places in Europe	1,600,000	650,000	2,250,000	1.72	1,350,000	60.00%
ASIA:						
British India	127,000	—	127,000	0.03	54,000	42.52%
China	78,827	150,000	228,827	0.05	140,000	61.18%
Japan [4]	990,874	—	990,874	1.27	303,592	30.64%
Turkey ‡	41,352	—	41,352	0.21	33,806	81.75%
Other Places in Asia	122,000	31,000	153,000	0.08	59,000	38.56%
AFRICA:						
Egypt [2]	95,303	—	95,303	0.40	68,128	71.49%
Morocco	34,694	7,000	41,694	0.42	27,440	65.81%
Union of South Africa	300,000	—	300,000	2.58	220,000	73.33%
Other Places in Africa	150,000	—	150,000	0.11	60,000	40.00%
OCEANIA:						
Australia [1]	827,862	—	827,862	11.22	489,246	59.10%
Hawaii	—	75,598	75,598	12.60	55,228	73.05%
New Zealand [4]	278,000	—	278,000	15.57	164,500	59.17%
Other Places in Oceania	16,600	8,400	25,000	0.03	6,000	24.00%

[1] June 30, 1945.
[2] January 1, 1946.
[3] March 31, 1946.
[4] March 31, 1947.

* Subscribers only.
† Including all Asiatic territory of the U.S.S.R.
‡ Including Turkey-in-Europe.

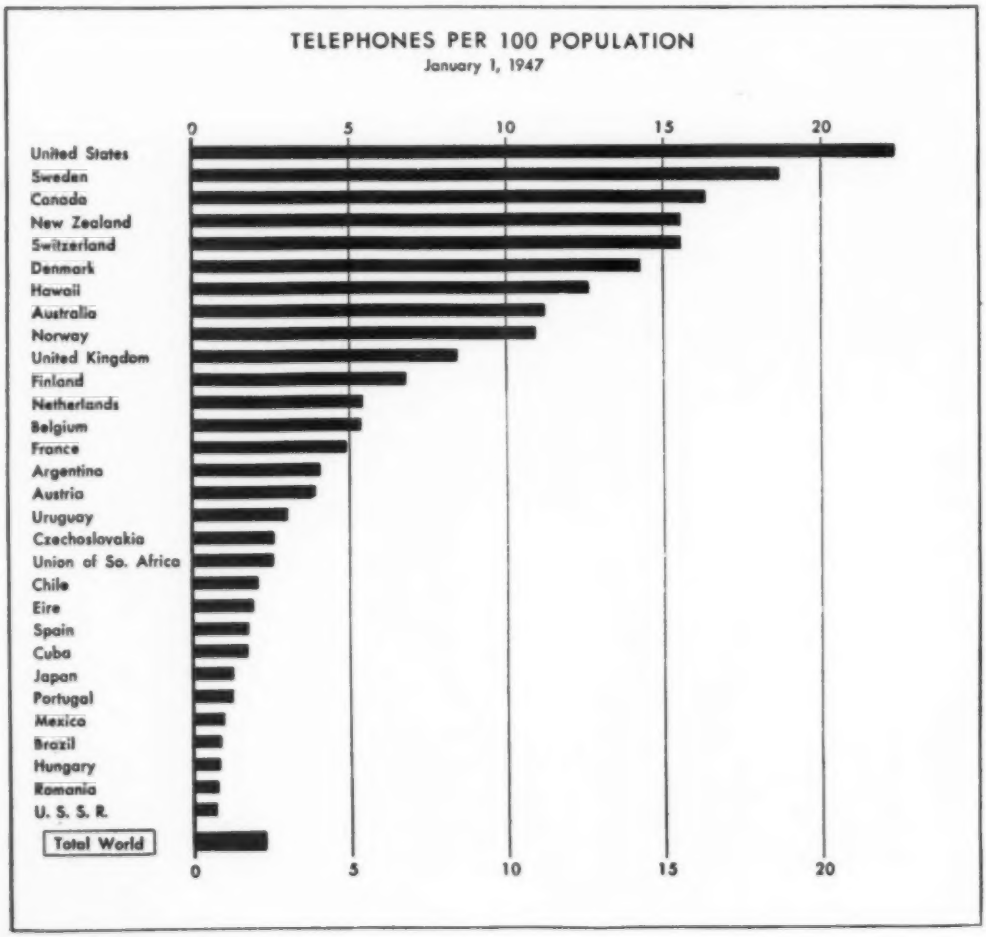
connected by radio telephone links to telephones on ships, railways, motor vehicles, and with those in 68 countries or territories overseas.

The tide of telephone calling in the United States during 1946 rose to a record high average of 128 million conversations each business day, so that the nation's voice channels were kept humming during the year by more than 42 billion telephone messages—or more than 300 completed conversations for each man, woman, and child in the nation. Fifty years ago, there was an average of only twelve telephone messages during the year for each person in the nation.

Ownership at the Start of 1947

GOVERNMENT-OWNED SYSTEMS in the world accounted for 17.6 million telephones, of which more than three-fourths were in the continent of Europe. Among those systems wholly or predominantly owned and operated by national governments, the largest eight * had in the aggregate some twelve million instruments

* The United Kingdom, France, the U.S.S.R., Sweden, Japan, Australia, Switzerland and the Netherlands.



TELEPHONE CONVERSATIONS AND TELEGRAMS[1]
Year 1946

Country	Number of Telephone Conversations	Number of Telegrams	Total Number of Wire Communications	Per Cent of Total Wire Communications		Wire Communications Per Capita		
				Telephone Conversations	Telegrams	Telephone Conversations	Telegrams	Total
Australia [2]	753,000,000	36,590,000	789,590,000	95.4	4.6	102.6	5.0	107.6
Belgium	370,000,000	7,782,000	377,782,000	97.9	2.1	44.2	0.9	45.1
Canada [3]	3,210,000,000	16,414,000	3,226,414,000	99.5	0.5	264.9	1.3	266.2
Denmark [3]	1,020,000,000	2,784,000	1,022,784,000	99.7	0.3	252.2	0.7	252.9
Egypt [3]	380,000,000	4,333,000	384,333,000	98.9	1.1	15.8	0.2	16.0
Eire	60,000,000	2,907,000	62,907,000	95.4	4.6	20.3	1.0	21.3
Finland	478,000,000	1,298,000	479,298,000	99.7	0.3	123.3	0.3	123.6
France	1,457,000,000	37,062,000	1,494,062,000	97.5	2.5	36.0	0.9	36.9
Japan	2,604,000,000	74,145,000	2,678,145,000	97.2	2.8	34.3	1.0	35.3
Norway [2]	463,000,000	7,897,000	470,897,000	98.3	1.7	152.3	2.6	154.9
Portugal	134,000,000	5,422,000	139,422,000	96.1	3.9	16.3	0.7	17.0
Romania	358,000,000	6,477,000	364,477,000	98.2	1.8	21.6	0.4	22.0
Sweden [3]	1,715,000,000	6,531,000	1,721,531,000	99.6	0.4	258.4	1.0	259.4
Switzerland	581,000,000	2,755,000	583,755,000	99.5	0.5	130.5	0.6	131.1
United States	42,280,000,000	211,000,000	42,491,000,000	99.5	0.5	301.2	1.5	302.7

[1] Telephone conversations represent completed local and toll or long distance messages. Telegrams include inland and outgoing international messages.
[2] Year ended June 30, 1945.
[3] Year ended December 31, 1945.

in service at the beginning of 1947, or one telephone for each group of thirty-four people. Of these eight government-owned systems—ranging down from four million telephones to one-half million telephones—Sweden has the highest telephone density with 18.64 telephones per 100 inhabitants, being second only to the United States.

Telephone Development by Leading Countries

THE LARGEST TELEPHONE network outside of the United States, that of the United Kingdom, is operated as a branch of the British Post Office. As of March 31, 1946, this administration reported 3,936,995 telephones, and the three "municipal" systems (serving the City of Hull and the Islands of Guernsey and Jersey) reported, at the beginning of that year, 39,941 telephones. During the summer of 1946 the United Kingdom passed the four million mark in the number of its telephones in service, or slightly more than seven percent of the world's total. When ranked according to the number of telephones serving each 100 of its population (8.43), it occupied tenth position among the countries of the world.

Among the communications systems of the world, the Canadian telephone system has risen to third place on the bases of both absolute size and number of telephones available to each group of 100 persons in the

TELEPHONE DEVELOPMENT OF LARGE CITIES, JANUARY 1, 1947

Country and City (or Exchange Area)	Estimated Population (City or Exchange Area)	Number of Telephones	Telephones per 100 Population
AUSTRALIA:			
Adelaide	374,000	48,001	12.83
Brisbane	382,000	53,804	14.08
Melbourne	1,206,000	192,187	15.94
Sydney	1,440,000	223,295	15.51
AUSTRIA:			
Graz	220,000	14,762	6.71
Linz	173,000	13,290	7.68
Vienna	1,538,000	137,327	8.93
BELGIUM:			
Antwerp	570,000	50,616	8.88
Brussels	925,000	148,360	16.04
Charleroi	270,000	21,277	7.88
Ghent	212,000	13,193	6.22
Liege	360,000	23,864	6.63
BRAZIL:			
Bello Horizonte	225,000	9,594	4.26
Nictheroy	160,000	7,944	4.97
Rio de Janeiro	2,070,000	159,076	7.68
Sao Paulo	1,466,000	88,348	6.03
CANADA:			
Hamilton	189,600	44,835	23.65
Montreal	1,198,000	265,447	22.16
Ottawa	252,000	66,018	26.20
Quebec	219,900	38,793	17.64
Toronto	903,100	298,911	33.10
Vancouver	371,000	103,544	27.91
CHILE:			
Santiago	1,055,000	62,199	5.90
Valparaiso	240,000	8,744	3.66
CHINA:			
Hong Kong	1,500,000	17,304	1.15
Peiping	1,700,000	24,130	1.42
Shanghai	4,000,000	94,317	2.36
Tientsin	1,400,000	17,557	1.25
NETHERLANDS:			
Amsterdam	798,000	78,262	9.81
Haarlem	197,000	16,188	8.22
The Hague	582,000	64,584	11.10
Rotterdam	706,000	50,545	7.16
Utrecht	200,000	17,537	8.77
NEW ZEALAND: [3]			
Auckland	265,000	41,524	15.67
Wellington	175,000	41,588	23.76
NORWAY: [1]			
Bergen	111,000	22,592	20.35
Oslo	435,000	96,423	22.17
PORTUGAL:			
Lisbon	781,000	46,930	6.01
Oporto	317,000	16,025	5.06
ROMANIA:			
Bucharest	1,017,000	69,959	6.88
SPAIN:			
Barcelona	1,129,000	73,314	6.49
Bilbao	218,000	16,518	7.58
Madrid	1,179,000	101,244	8.59
Seville	335,000	14,659	4.38
Valencia	556,000	16,627	2.99
Zaragoza	288,000	10,593	3.68
SWEDEN: [2]			
Göteborg	315,000	87,511	27.78
Malmö	171,000	40,993	23.97
Stockholm	834,000	325,765	39.06
SWITZERLAND:			
Basel	169,000	57,284	33.90
Bern	140,000	50,973	36.41
Geneva	125,000	44,196	35.36
Lausanne	102,000	29,057	28.49
Zurich	384,000	110,555	28.79

COLOMBIA: [2]			
Bogota	415,000	18,702	4.51
CUBA:			
Havana	873,000	61,169	7.01
DENMARK: [2]			
Copenhagen	950,000	265,451	27.94
EGYPT: [2]			
Cairo	1,500,000	28,921	1.93
EIRE:			
Dublin	507,000	32,808	6.47
FINLAND:			
Helsinki	394,000	80,761	20.50
Turku (Abo)	105,000	9,890	9.42
FRANCE:			
Bordeaux	254,000	29,118	11.46
Lille	189,000	19,862	10.51
Lyon	461,000	58,354	12.66
Marseille	636,000	51,602	8.10
Nantes	200,000	14,543	7.27
Nice	211,000	19,491	9.24
Paris	2,729,000	630,551	23.11
HUNGARY:			
Budapest	1,500,000	49,776	3.32
JAPAN:			
Kobe	445,000	13,416	3.01
Kyoto	917,000	51,427	5.61
Nagoya	721,000	19,434	2.70
Osaka	1,297,000	63,152	4.87
Tokio	3,820,000	119,806	3.14
Yokohama	709,000	7,949	1.12
MEXICO:			
Guadalajara	262,000	10,965	4.19
Mexico, D. F.	1,780,000	122,224	6.87
Monterrey	226,000	12,225	5.41
URUGUAY:			
Montevideo	710,000	51,051	7.19
UNITED STATES:			
New York	7,676,500	2,213,828	28.84
Chicago	3,675,000	1,322,411	35.98
Detroit	2,179,000	660,036	30.29
Philadelphia	2,018,000	558,050	27.65
Los Angeles	1,865,000	672,815	36.08
Cleveland	1,248,000	423,885	33.97
St. Louis	1,057,200	307,345	29.07
Pittsburgh	1,036,500	320,061	30.88
Baltimore	1,021,800	244,394	23.92
Total 9 exchange areas with more than one million population	21,777,000	6,722,825	30.87
Washington, D. C.	940,000	386,117	41.08
Milwaukee	837,200	244,092	29.16
San Francisco	830,500	369,365	44.48
Boston	721,800	253,735	35.15
Seattle	640,000	215,751	33.71
Houston	583,300	170,718	29.27
Indianapolis	504,000	163,442	32.43
Total 15 exchange areas with 500,000 to one million population	9,954,900	3,281,023	32.96
Portland (Oregon)	484,000	154,316	31.88
Denver	400,000	150,012	37.50
St. Paul	348,000	122,531	35.21
Omaha	283,000	95,305	33.68
Hartford	282,900	101,739	35.96
Oklahoma City	266,700	87,186	32.69
Richmond	256,000	82,981	32.41
Total 38 exchange areas with 200,000 to 500,000 population	11,730,500	3,346,822	28.53
Total 62 exchange areas with more than 200,000 population	43,462,400	13,350,670	30.72

NOTE: There are shown, for purposes of comparison with cities in other countries, the total development of all cities in the United States in certain population groups, and the development of certain representative cities within each of such groups.

[1] June 30, 1945. [2] January 1, 1946. [3] March 31, 1947.

Dominion. In regard to the number of telephone messages per capita, it is second to that of the United States, with 265 completed conversations per year for each inhabitant. Of Canada's 2,023,700 telephones at the beginning of 1947, all but 15 percent were operated by private companies.

A total of 1,997,335 telephones within its borders makes France the fourth largest telephone system in the world. More than 31 percent of the French telephones are located within the Paris exchange area. Today, two thirds of France's telephones are dial operated, and Frenchmen in the year 1946 picked up their telephones and conversed almost 1.5 billion times, for an average of 36 calls per capita.

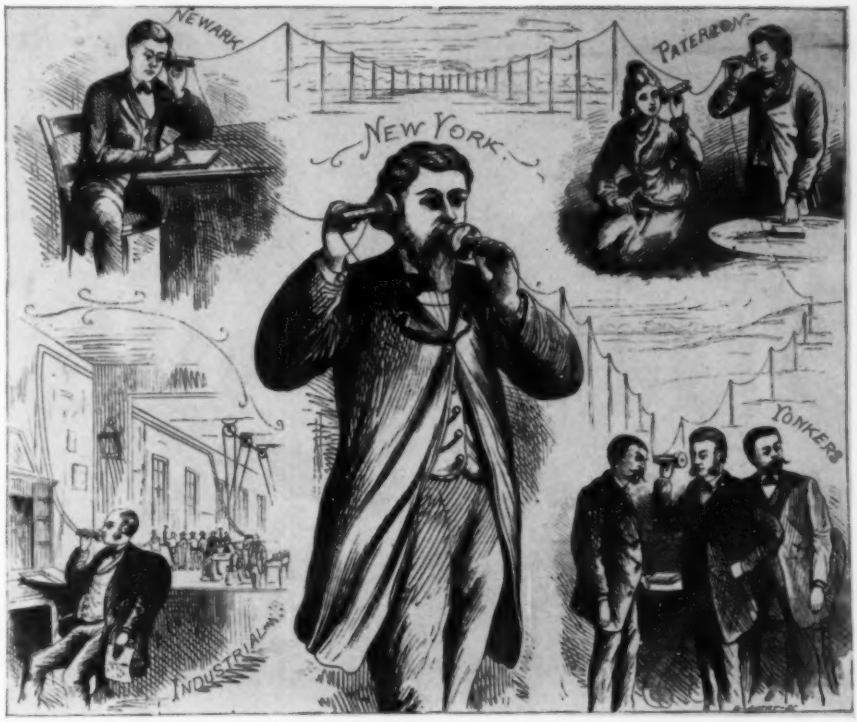
Fifth in point of absolute size, second in telephone density, is the Swedish telephone system. Twenty-six percent of the present Swedish system is located within the Stockholm area. Of Sweden's 1,244,073 telephones at the beginning of 1946, 56 percent were of the dial type. During the year 1945, more than 1.7 billion telephone messages were routed through the Swedish network, so that, on the average, each individual in that kingdom completed 258 telephone conversations during the year.

Among the South American republics, Argentina retained its leadership with a total of 590,000 instruments in service for a development of 4.05 telephones per 100 inhabitants at the beginning of 1947. Brazil at the same time had 439,500 telephones in service, so that together these two countries accounted for almost three-quarters of all the telephones in South America. In point of telephone density, Uruguay ranked second in South America, since each 100 people in that republic had more than 3 telephones available to them.

Telephone Development in Cities

AMONG ALL THE COMMUNITIES of the world (exclusive of those in the United States) having a population greater than 50,000, there are less than 100 cities whose telephone density is greater than *ten* telephones for every 100 of the population; yet here at home there are almost 200 cities within this category whose telephone density exceeds *twenty* telephones per 100 population. In all communities of less than 50,000 population, the United States shows a total telephone development of more than 17 per 100 inhabitants. In this respect, Sweden, Switzerland, and Canada rank next in the order named with developments of 14, 11 and 10, respectively. No one city in the United States embraces more than seven percent of the country's telephones. Yet, the three large urban centers of New York, Chicago and Los Angeles together had far more telephones than the largest telephone system in the world outside of the United States.

A telephone network larger than that of Norway serves the 831 thousand people of the San Francisco exchange area, so that the measure of telephone development for this metropolis is 44.48 telephones for each 100 people, a figure surpassing that of any other large metropolitan telephone exchange area in the world. Two telephones for 1.35 billion people in the world of 1876! Almost one telephone for every *two* people in the San Francisco of 1947!



The New Bell Telephone

From the *Scientific American* of October 6, 1877

Our large engraving . . . affords an excellent idea of how the instrument is used, and also of about the extent of circuit over which it is known to be capable of successful operation. We suppose the closed wire circuit to extend from New York to Newark, thence to Paterson and Yonkers, and back to New York, a distance of about 50 miles air line, or some 70 miles by railway. The figure marked New York may be considered as a public speaker delivering a lecture to be heard in the towns mentioned. He talks into one telephone while he holds another to his ear, in order, for example, to hear the applause, etc., of his auditory; or he may be maintaining a discussion or debate, and he then hears his adversary's replies or interruptions. Now, at Newark there is simply a reporter, who takes down the speech phonographically; the words pass on through that telephone and reach Paterson. Here we show two persons, each with a telephone, the two instruments being connected. . . . In Yonkers we show three persons listening to a single instrument, which may be done in a very quiet room. Finally, in a side sketch we show how the telephone is arranged to serve as a speaking trumpet between office and shop in a factory. . . . The telephone has advanced considerably beyond the status of a "beautiful scientific toy," which many hastily pronounced it. . . .

A Tribute to an Outstanding Leader Who Four Decades and More Ago Guided the Development and Research Activities of the Bell System in Its Most Critical Period

Hammond V. Hayes: 1860-1947

Roger B. Hill and Thomas Shaw

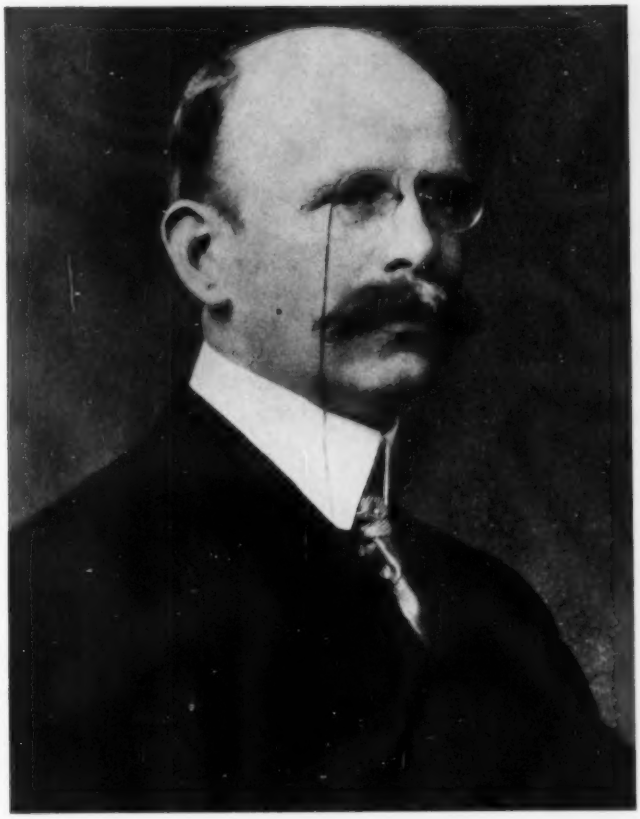
With an introductory note by

William H. Harrison

The death of Hammond Vinton Hayes last March severed another of the few remaining ties with the founding fathers of telephony. He was a leader among the company of men who, combining their practical skill with vision for the future, took Bell's concept and instruments and went on to build many of the foundations of the telephone system and telephone service as we know them today. In their approach to their task this group also laid a basis for much of the progress later achieved by others. Mr. Hayes's own contributions to the telephone art were great: he provided a high calibre of leadership, which expressed itself in his personal relations with his staff members and in his creation of an able organization; and through his inventive and engineering skill he solved, or guided the solution of, problems which were stifling the growth of the service. How Mr. Hayes brought these accomplishments about, and what were their consequences, Messrs. Hill and Shaw relate in the following pages. The period covered was a critical one in telephone history, and men of long service in the Bell System will read the narrative with a lively recollection of difficulties overcome, of milestones passed with invigorated stride. Younger members will get from it perhaps a better understanding of what it must have been like to try to serve the public during the first twenty years or so after the telephone first spoke—and a realization that today's problems can be solved even as were those heavier ones of half a century ago. It is a stimulating story of ability, of perseverance, of obstacles surpassed and triumphs won, told in tribute to one of the outstanding leaders in telephone history.

WILLIAM H. HARRISON

Vice President, A. T. & T. Co.



Hammond Vinton Hayes

ON MARCH 23, 1947, the Boston Sunday papers carried notices of the death of Hammond V. Hayes at his Beacon Street residence on the previous day. Mentioning that prior to his retirement in 1930 he had been president of the Submarine Signal Corporation, they also stated that earlier in his life he had been in charge of engineering work for the American Bell Telephone Company and the American Telephone and Telegraph Company.

To many who have played important roles in the development of the telephone art, however, the name of Hammond Vinton Hayes will mean far more than such a casual reference implies. Out of the flood of returning memories, Mr. Hayes will emerge as the outstanding leader who guided the research and development activities of the Bell System through what was perhaps its most critical period—from 1885 to 1907—through twenty-two years when serious obstacles to success were being encountered at a rate far higher than during any equal period since, and yet a period when the miles of exchange wire in the Bell System increased over sixty-fold.

To guide the technical development of the telephone system during these years of stress, a man of exceptional caliber was required. Such a man was found in Mr. Hayes. Endowed with persistence, determination, and ability from a long line of New England ancestry, and possess-

ing an excellent technical training and an innate keenness of mind, he seemed instinctively able to select the most suitable assistants and to inspire them with enthusiasm for the tasks he assigned. His interest in every project continued to its culmination, and he never wavered in his solicitude for the progress and well being of his associates. He seemed to have been prepared by fate for the existing need.

Family Background

ABOUT THE YEAR 1680, during the early colonial period, a certain John Hayes arrived from Scotland and settled in Dover, New Hampshire. Hammond V. Hayes was one of his direct descendants of the seventh generation. His father, William Allen Hayes, was born in South Berwick, Maine, and on a trip through the West as a young man met Elizabeth Vinton, daughter of General David Hammond Vinton, and married her in Madison, Wisconsin. The two children of this marriage, Hammond Vinton and William Allen, were born in Madison on August 28, 1860, and June 11, 1862, respectively.

Returning to New England in 1864, the family settled in Cambridge, Mass. During the years that followed, Mr. Hayes's father held many important positions, among them treasurer of the Atlantic and Pacific Railway Company and of the Boston, Newport, and New York Steamship Company. In the meantime, his two sons were attending schools in Cambridge and Boston. Hammond V. Hayes was graduated from the Boston Latin School, and from Harvard University in the class of 1883. He then studied at Massachusetts Institute of Technology, and took graduate work at Harvard, where he received his Master's degree and the second Doctor's degree in Physics to be awarded by Harvard. He never married. On December 7, 1885, he joined the American Bell Telephone Company in Boston—at that time the parent company of the Bell System—and was placed in charge of the recently created Mechanical Department.

Rapid and Effective Technical Development Needed

FOR THOSE familiar chiefly with the telephone system of the present day, with its multi-channel carrier systems that by open wires, cable, and radio carry the voice completely around the world, it is difficult to realize the crude state of telephone communication in 1885, when Mr. Hayes took over responsibility for its technical growth. Not only was telephony a completely new art, but the entire electrical industry was in its infancy. The telegraph was well established, but the Brush arc light and the Edison incandescent electric lamp were only just beginning to be used, and they were of no assistance in the development of the telephone art. To a large extent, the entire theory of telephone transmission was yet to be developed.

In the telephone industry itself, progress was being made in installing telephones and the exchanges needed to interconnect them, but the impediments were burdensome.

At each telephone there had to be batteries to supply talking current, and a magneto ringer for signaling the operator. The batteries in par-

ticular required continual and expensive maintenance, since their useful life was relatively short.

The use a subscriber got from his telephone was definitely restricted. Anything approaching satisfactory talking conditions could not be obtained beyond a very limited radius. The currents that could be handled in the telephone transmitter of that time were small, and in their passage over the line—for the most part a single wire with ground return—were not only soon dissipated by the losses, but were seriously interfered with by innumerable noises, and often by crosstalk from other circuits on the same line.

Switching facilities were very inadequate. When the subscribers finished talking, they had to "ring off" to notify the operator to take down the connection. When they neglected to do this, as they frequently did, the operator had to listen in on the line to find out whether or not it should be disconnected.

Overhead wires on lower Broadway, New York, in 1890

Lacking satisfactory cable and consisting for the most part of iron wire carried on roof tops and on poles down city streets, the distributing system of the time provided no suitable foundation on which a permanent and expanding system could satisfactorily be built.

Only rapid and effective technical development could transform this inchoate but rapidly growing system into the soundly based, scientifically designed structure which it later became.

It was this assignment which Mr. Hayes took over.

Early Organization

UNTIL 1883, the technical work of the American Bell Telephone Company had been carried on by two groups: the Electrical and Patent Department, which studied available patents and new apparatus, and performed all the engineering functions being carried on; and the Stock and

HEADQUARTERS TECHNICAL STAFF
AMERICAN BELL TELEPHONE COMPANY
DECEMBER 31, 1885
29 EMPLOYEES

ELECTRICAL AND PATENT DEPT.	MECHANICAL AND TESTING DEPT. (H.V. HAYES IN CHARGE)	STOCK AND PACKING DEPT.
SPECIAL DEVELOPMENT WORK: E. BERLINER W. W. JACQUES J. H. FLANNIGAN G. H. E. TROUVELOT	GENERAL EXPERIMENTAL WORK: MORGAN BROOKS E. H. LYON	J. R. QUICK A. F. HALL T. FRANCIS MAGUIRE F. MARTIN H. G. MCKENNEY
PATENTS: T. D. LOCKWOOD V. M. BERTHOLD G. W. PIERCE D. E. RICHARDS F. J. SCHWARTZ W. B. VANSIZE	INSTRUMENT INSPECTION: W. L. RICHARDS THOS. F. MAGUIRE G. K. THOMPSON J. B. WILKINS	
SPECIAL WORK W. A. HOVEY JOSEPH LYONS	SHOP: H. R. MASON W. P. RICHARDS G. W. THOMPSON	
	CLERICAL: F. E. DONOHOE	
	OFFICE BOY: F. C. BROWN	

Testing Department—its function indicated by the name.

In 1883, an Experimental Shop was organized to supplement the activities of the Electrical and Patent Department. In June, 1884, its name was changed to the Mechanical Department—although today the functions it was to perform would be called development and research—and Ezra T. Gilliland was put in charge. Mr. Gilliland resigned in November, 1885, when the department was only about a year old, and thus the structure and effectiveness it later achieved were derived from the contributions of Mr. Hayes, who took control of it the following month.

This Mechanical Department of which Mr. Hayes took charge was the first formal department in the continuous chain of research and development organizations of which the present representative is Bell Telephone Laboratories. During the following forty years, it went through many metamorphoses, changing its name, adding or dropping functions, and shifting its organizational plan; but throughout these years and ever since, it has been responsible for developing the apparatus and systems needed to provide the best telephone service possible in the existing state of the art, and through all the later years for carrying on research to discover and correlate basic laws and theory.

The first major modification of the engineering organization after Mr. Hayes assumed control of the Mechanical Department was in 1891, when an Engineers Department under Joseph P. Davis was formed to standardize plant construction and operating methods. In 1891, therefore, the two technical departments were the Engineers Department under J. P. Davis, and the Mechanical Department under Mr. Hayes. Considerably Mr. Hayes's senior both in age and Bell System experience, Mr. Davis was placed nominally in charge of both the Engineers and the Mechanical Departments in 1894, but Mr. Hayes continued to guide the Mechanical Department independently as before.

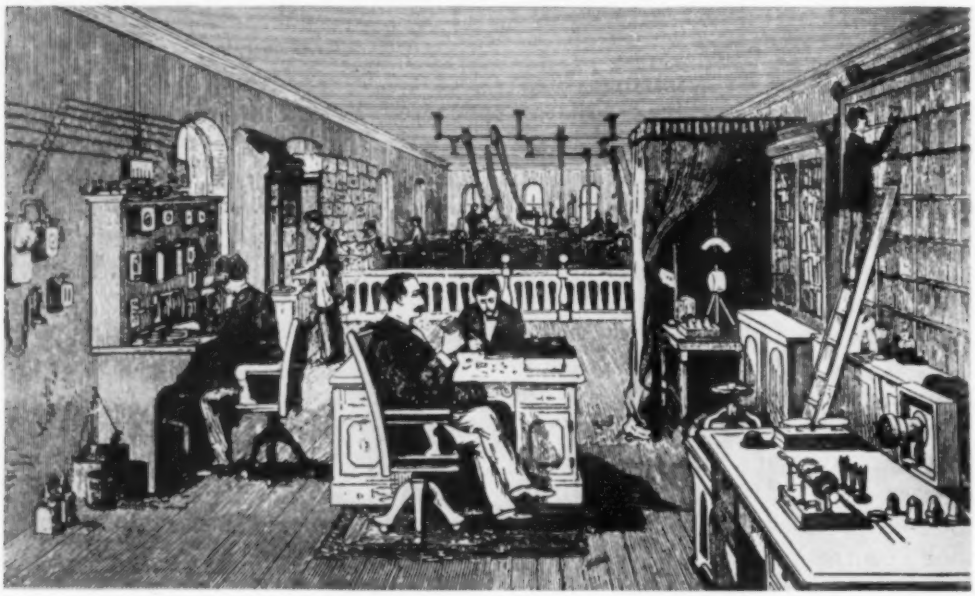
By 1902, Mr. Davis was in poor health and unable to continue active direction of the Engineers Department. As a result, the Engineers and the Mechanical Departments were merged into a single organization called the Engineering Department and placed under a three-man committee, which nominally reported to Davis. Mr. Hayes was one of this directing committee, and was responsible for preparing the annual reports of the Engineering Department for Mr. Davis during this period. On January 1, 1905, however, Mr. Davis resigned, and at this time Hayes was made Chief Engineer and placed in charge of the combined Engineering Department.

Opposite: Organization chart of the headquarters technical staff of the American Bell Telephone Company in 1885

The New Parent Company

IN THE MEANTIME, other changes had been taking place.

The year before Mr. Hayes joined the Bell System, an experimental metallic circuit, using hard-drawn copper wire, had been built between



The laboratory of the Mechanical Department, at 101 Milk Street, Boston, in 1884; from an old wood engraving published in the "Scientific American"

Boston and New York. This was the Bell System's first long distance circuit. Transmission over it was good enough, and optimism was strong enough, to give hope for the attainment of even greater distances with improvements that seemed possible in the near future.

To provide for the extensive long distance business that could now be foreseen, the American Telephone and Telegraph Company, a subsidiary of the American Bell Telephone Company, was incorporated in 1885 to construct and operate long distance lines. Its headquarters were in New York City, and it built up its own Engineering Department to carry out its various projects.

In 1899, a reorganization was carried out in which the American Telephone and Telegraph Company absorbed the American Bell Telephone Company and became the parent company. No change was made in the engineering organizations at this time. The parent company's Engineering Department remained in Boston and the Long Lines Engineering Department in New York. Since the American Telephone and Telegraph Company was now the parent company, Mr. Hayes was Chief Engineer of the American Telephone and Telegraph Company when he took charge of the combined Engineering Department in 1905.

Putting Wires in Cables

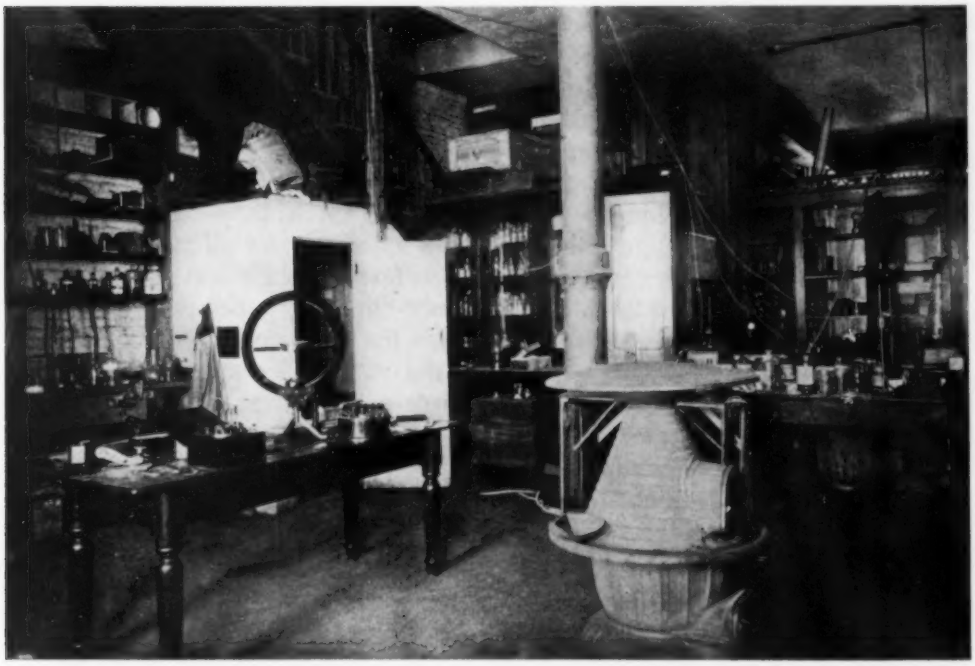
FOR SOME YEARS before Mr. Hayes joined the Bell System, there had been need in certain places for a more compact transmission system than the open-wire line. The use of insulated wires in a protecting cover was the sort of thing required, and as early as 1879 cables had been placed over the Brooklyn Bridge. These were

single-wire ground-return circuits and had the difficulties inherent in this type of circuit superimposed on the many other difficulties of cable operation. All of the cables, moreover, for the next eight or nine years employed wires insulated with rubber or gutta-percha, or with cotton impregnated with a moisture-proofing compound. They were all very unsatisfactory because of their high electrostatic capacitance, and could be used only over very short distances.

By the year 1887, the need in the large cities for placing the wires under ground in metallic-circuit cables had become so pressing that a group of telephone executives and engineers was called together by the parent company to make a thorough study of the requirements of the Bell operating companies and to develop improved types of cables to meet these requirements. This group, called the Cable Committee, met at intervals over a period of years, and Mr. Hayes was one of its members.

Specifications resulting from the 1887 conference called for a cable of 18-gauge twisted-pair conductors, each with two wrappings of dry cotton. The spaces in the core and between the core and lead pipe were filled with paraffin or a resinous compound. The electrostatic capacitance was not to exceed .20 microfarad per mile, each wire tested against all others grounded.

DURING THE YEAR 1888, J. A. Barrett, of the long distance company, and W. D. Sargent, of the New York and New Jersey Telephone Company,



The laboratory of the Mechanical Department at 141 Pearl Street, Boston, in 1886

in a long series of experiments demonstrated the advantages of paper as cable insulation. As the result of trials of this new type of insulation, specifications were issued by the Cable Committee in 1891 for a dry-core 19-gauge twisted-pair cable insulated with manila paper, and with a maximum electrostatic capacitance of .085 microfarad per mile. In the conference specifications issued by the American Bell Telephone Company in 1892, the electrostatic capacitance was reduced to .080 microfarad per mile. This cable furnished the answer to the underground problem, permitting the wholesale replacement of open wires in the cities, and making it possible, for the first time, to engineer the telephone plant on a systematic and economical basis.

DURING THE YEARS that followed, improvements in the methods of cable manufacture permitted the number of pairs of 19-gauge wires that could be contained in a full-size cable to be increased from 100, in 1892, to 300, in 1901. In this latter year, improvements in the instruments and apparatus had made it possible to begin extensive use of 22-gauge cable in the exchange plant. By 1902, 600-pair 22-gauge cable had been made available to the operating companies of the Bell System.

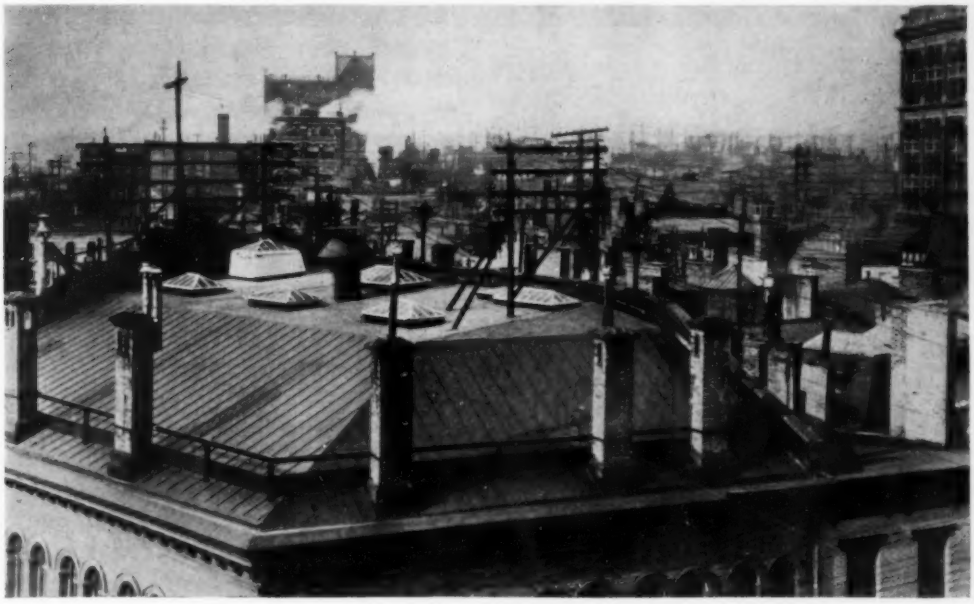
Early in the year 1898, Mr. Hayes's department began work on the development of cables suitable for toll operation, to permit the long distance circuits entering large cities to be placed under ground, thus avoiding frequent service interruption by storms. Since the standard 19-gauge cable was not good enough for this service, and since loading had not yet been invented, it was necessary to employ much larger conductors, and also in some instances lower capacitance cable construction. The earliest of these new cables was installed between Boston and Lynn in 1898. During this and the following years, other cables employing 16-, 14-, or 13-gauge conductors were installed in the Boston and New York metropolitan areas, and the use of still larger conductors received serious consideration.

The development of paper-insulated cable carried out under direction of the Cable Committee in the years following 1887 was of tremendous value to the Bell System. Besides permitting the elimination of tall multi-armed pole lines and roof-mounted racks that enmeshed the larger cities, it enormously decreased inductive disturbances from outside the cable, avoided disruption of open-wire lines by sleet storms, and opened the door to more economical construction for long-distance circuits.

Improved Transmitters

ALTHOUGH cables tended to give quieter circuits by eliminating outside interference, their losses were higher than those of open-wire lines, and thus the need for higher speech volumes at the telephone transmitter became greater than ever.

In Bell's original transmitter, the voice voltages were generated electromagnetically, and only the power of the voice was available for their production. The discovery of microphonic action, and the development in 1878 of the Blake transmitter based on this discovery, greatly increased transmitter power. With



Roof-top construction in down-town New York in 1888

the microphone, transmitter power is supplied by a battery, and the microphonic contact acts as a valve to release more or less power to the line in response to the voice waves. No longer were the electrical signals limited to the small amount of power in the speech waves. Although a great improvement in this respect compared to the electro-magnetic transmitter, the Blake transmitter was still strictly limited in output because it employed only a single contact.

The discovery by Hunnings that microphonic action could be obtained between masses of granular carbon suggested an avenue to larger transmitter outputs, since with many contacts in place of a single one, more current could be handled by the transmitter. Attempts to utilize this discovery were unsuccessful for several years, since no way could be found to prevent the carbon particles from packing together and making the transmitter inoperative.

This difficulty was overcome by the invention, in 1890, by Anthony C. White of Mr. Hayes's staff of the "solid-back" transmitter. This instrument used a relatively small amount of granular carbon in a carbon chamber, or "button," so contrived that the motion of an electrode controlled by the diaphragm kept the granules agitated sufficiently to prevent them from forming a compact mass. This instrument was called the solid-back transmitter, since the rear electrode that made contact with the granular carbon was fixed in position. It was a much more powerful instrument than the solid-electrode Blake transmitter which it superseded. With numerous improvements, this basic design remained in use until it was replaced by the modern handset.

Developing a Common Battery

WHILE the microphonic transmitters gave marked improvement in transmission, the local batteries that had been installed to supply them with current proved very expensive to maintain. What was desired was a single large battery at the central office that would supply all the subscribers, and although this idea was not new, no satisfactory way of applying such a battery had been found. A single battery supplying all the lines tends to couple all the lines together and to give excessive crosstalk, and no satisfactory way around the difficulty had been found.

Work seeking a common-battery system was started in the Mechanical Department in 1889. A large amount of experimental effort by Mr. Hayes and his staff was required, since it was desired to use the common battery for signaling as well as talking so as to make magneto generators at the subscribers' premises also unnecessary.

THE FUNDAMENTAL PROBLEM of avoiding crosstalk was solved by Mr. Hayes's invention of the repeating-coil system of battery supply, which in improved form has been in universal use in the Bell System common-battery switchboards since that time.

With the common-battery system, both the batteries to furnish transmitter current and the magneto generators for signaling the operator were done away with at subscribers' stations, since the new system was so arranged that the operator could be signaled merely by removing the receiver from the hook. This closed the line circuit and, through a relay at the switchboard, caused a tiny electric lamp in front of the operator to glow. Lamps were also introduced as supervisory signals in the cord circuits, giving the operator at all times a visual indication of the status of the connection and making it unnecessary for her to listen in or disturb the service in any way.

The immediate advantages of the common-battery system, to which C. E. Scribner, J. J. Carty, and several other inventors also made important contributions, were a great improvement in the speed and quality of service, and a very large reduction in maintenance expense. It was one of the outstanding events in switchboard progress, and in the years to follow it opened the way to many additional improvements that would have been difficult or impossible without it.

THE FIRST common-battery board, installed at Lexington, Mass., in 1893, was a non-multiple board. The first multiple board with common battery for both talking and signaling, and employing lamps for line and supervisory signals, was installed at Louisville, Kentucky, in 1897. This type of board became known as the No. 1 relay board, and was widely used in large exchanges. By the early 1900s, common-battery relay boards had been installed in most of the larger cities throughout the United States.

Since the highly ingenious split repeating coil employed in the common-battery switchboard and the circuit arrangement used with it were largely the personal contributions of Mr. Hayes, the method of common-battery supply used in the Bell Sys-

tem has generally been referred to in textbooks as the "Hayes System". Besides recognizing the many advantages of the system, Mr. Hayes continuously sponsored its general application and followed its operating successes. In 1895 he collected statistics showing that with common battery the instrument troubles were only one fourth as frequent as with the magneto system, and that, as a result, subscriber stations would require inspection only at infrequent intervals. The following year he estimated that with the common-battery system, the average speed of operation would be increased by forty percent, due to automatic signaling; and that the cost of battery maintenance would be reduced by seventy-five percent, due to the centralized battery. He also pointed out the advantages the system offered for registering calls by meter, for the application of coin-box service, and for the extensive introduction of private branch exchanges.

Open-wire Transposition

ANOTHER DEVELOPMENT to which Mr. Hayes's department made outstanding contributions was the design of transposition systems for open-wire lines.

In 1886 the first line of the newly formed long distance company was completed between New York and Philadelphia. Originally it carried

A group of Mechanical Department engineers at 127 Purchase Street, Boston, in 1889. Seated, W. L. Richards, H. D. Sears, Chauncey Smith, Jr., W. J. Hopkins; standing, E. H. Lyon, Anthony C. White

twelve metallic circuits of hard-drawn copper wires—the first instance of a large number of metallic circuits being carried on the same pole line. Tests soon showed that the crosstalk was as serious as it had been with the grounded circuits previously employed. This difficulty was overcome after months of hard work by J. A. Barrett, consulting engineer employed by the long distance company. Out of this work of Barrett's came the ABC system of transpositions—the first to come into general use. Although employed for many years, it was found to be inadequate as the business grew, and in 1898 was replaced by the so-called Standard or four-arm system. During 1904, an elaborate series of measurements of direct capacitances was made by E. H. Colpitts of Mr. Hayes's staff upon which rested much of the work of transposition design that was done in succeeding years.

Adoption of Coil Loading

OF THE many transmission improvements made during the Hayes period, one of outstanding importance was the adoption of loading.

In the late 1880s and early 1890s, mathematical studies by Vaschy and Heaviside had indicated that it should be possible to improve transmission over a telephone line by artificially increasing the distributed inductance. They had also speculated on the possibility of approximating the beneficial effects of uniformly distributed inductance by inserting low-resistance inductance coils at intervals along the line. Rules for spacing the coils, however, were not worked out, nor were suitable types of coils developed.

In 1894, when transmission over long open-wire lines was being seriously impaired by the (non-loaded) entrance cables at their terminals, theoretical studies by John Stone Stone, of Mr. Hayes's staff, led to the proposal to replace them by continuously loaded cable designed to match the impedance of the open-wire lines. A specific design for such a "bi-metallic wire" cable resulted in a patent to Stone in 1897. Early in 1898, Mr. Hayes obtained an appropriation to cover further research and development of this type of cable for general underground use. The following year, shortly before Mr. Stone resigned, Mr. Hayes transferred responsibility for this research to Dr. George A. Campbell—who had joined his staff in the Fall of 1897.

STARTING in February, 1899, Campbell's approach quickly convinced him that there would be substantial advantages in concentrating on coil loading instead of continuous loading. Work on continuous loading was accordingly dropped, and a comprehensive solution of the fundamentally important problem of coil spacing was soon reached. His theory was experimentally verified in an extensive series of laboratory tests on reels of actual cable in September, 1899. E. H. Colpitts assisted Campbell in these experiments, and subsequently made important contributions in many other phases of the development work.

The development work which followed the 1899 laboratory tests culminated in successful installations of

A group of instrument inspectors and members of the Stock and Packing Department at 127 Purchase Street in 1889: G. K. Thompson, Frank Martin, J. B. Wilkins, A. M. Dittmer, John Daly, J. W. O'Donnell, A. F. Hall

experimental types of solenoidal air-core loading coils on two 24-mile cable circuits in the Boston exchange area, completed May 18, 1900, and on a 670-mile, 104-mil, open-wire line completed July 2, 1900. After an adequate test period, the experimental loaded circuits were used in regular commercial service for several months.

Shortly before the installation of the experimental cable loading, the parent Bell company learned that Professor M. I. Pupin, of Columbia University, had independently worked out a theoretical solution of the coil loading problem. On June 19, 1900, two United States patents were issued to Professor Pupin. The conflicting claims of the Pupin and Campbell applications resulted in extended interference proceedings which ended, on April 6, 1904, in an award to Pupin on the basis of two weeks' priority in disclosure. Before the interference action had gone far, Pupin's rights in the invention were purchased to protect the parent company's interest whichever way the case might be decided.

ALTHOUGH the success of the 1900 trial installations quickly built up a substantial demand for loading, the commercial applications had to be deferred pending the development of satisfactory loading coils. Priority was given to open-wire loading, and by April, 1901, a very satisfactory toroidal type iron-wire core design

had been developed by H. S. Warren of Mr. Hayes's staff. This coil remained standard for about ten years, when a redesign became necessary because of the development of phantom-group loading.

Manufacturing difficulties that delayed the initial use of this design were solved in time to permit the opening of service on an existing 165-mil line between New York and Chicago in November, 1901. In May, 1902, commercial service was inaugurated on three 104-mil loaded open-wire lines between Philadelphia and Chicago. Experience gained in developing open-wire loading coils permitted the use of satisfactory toroidal type loading coils on the first commercial loaded cable project, a 19-gauge underground cable between New York City and Newark, N. J., completed in August, 1902. Prior to the invention of loading, a relatively expensive 13-gauge non-loaded cable had been planned for this route. Thus from the very beginning the use of loading yielded large economies in the cable plant of the metropolitan areas.

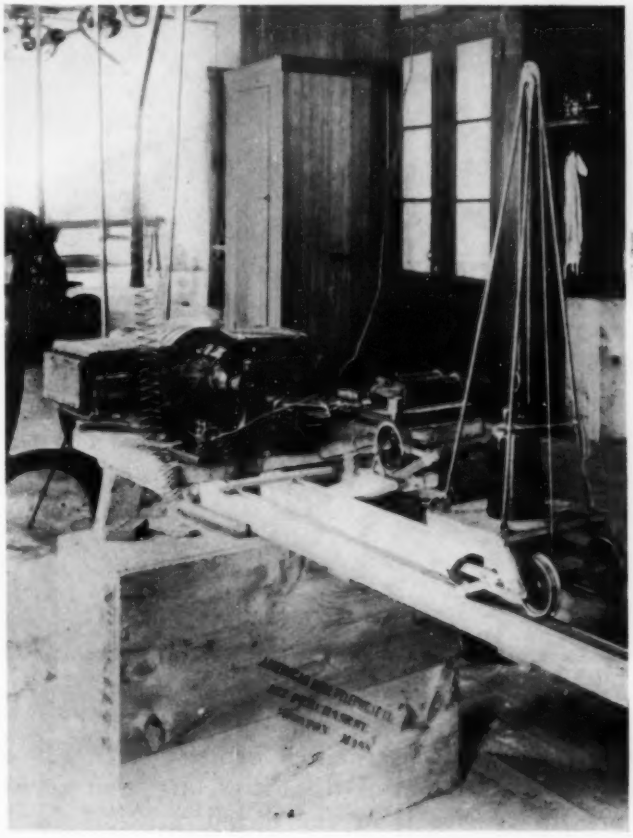
SINCE COIL-LOADED LINES completely suppress the transmission of frequencies above the cut-off frequency, which is a function of the coil inductance and spacing, and since the cost of loading is related to the cut-off frequency, a very important phase of the early development work was that of determining the minimum cut-off frequency that would be satisfactory. The 1899 laboratory tests carried the cut-off up to 11,000 cycles, but for the early commercial open-wire loading the cut-off frequency was reduced to 4100 cycles. Experience with these circuits and further laboratory tests finally resulted in 1904 in the adoption of 2300 cycles as the initial standard cut-off frequency. This standard so well met the early transmission service needs that the first increase in standard cut-off frequency did not occur until 1918.

The early applications of loading to open-wire lines were beset with many difficulties that could not be solved by theoretical studies or laboratory experiments, including the insulating properties of available line insulators, lightning protection devices, and the coördination of the coil-spacing and line transposition systems. Thus it happened that the final standard practice for loading 104-mil lines did not evolve until 1905. Generally satisfactory performance of loading on 165-mil lines was not obtained until the development of better line insulation about 1910.

The commercial exploitation of loaded cables went forward rapidly after the installation between Newark and New York, and resulted by 1904 in the adoption of loading-system standards that remained in good standing for two decades. A cable was installed between Boston and Worcester in 1904, and between New York and Philadelphia and New York and New Haven in 1906. Before the end of 1907 about 60,000 loading coils had been installed on some 86,000 miles of cable circuit.

DURING THE YEAR 1904, the commercial use of open-wire phantom circuits was made possible through the development of the 37A phantom circuit repeating coil, designed by H. S. Warren and described in a circular

issued to the Associated Companies in April of that year. The creation of an additional or phantom circuit from two physical circuits had occupied the attention of telephone engineers for many years, but the solution had been delayed until the development of Mr. Warren's toroidal coil—which used winding machinery developed for loading coils.



Part of the testing laboratory at 127 Purchase Street in 1889

The First Repeater

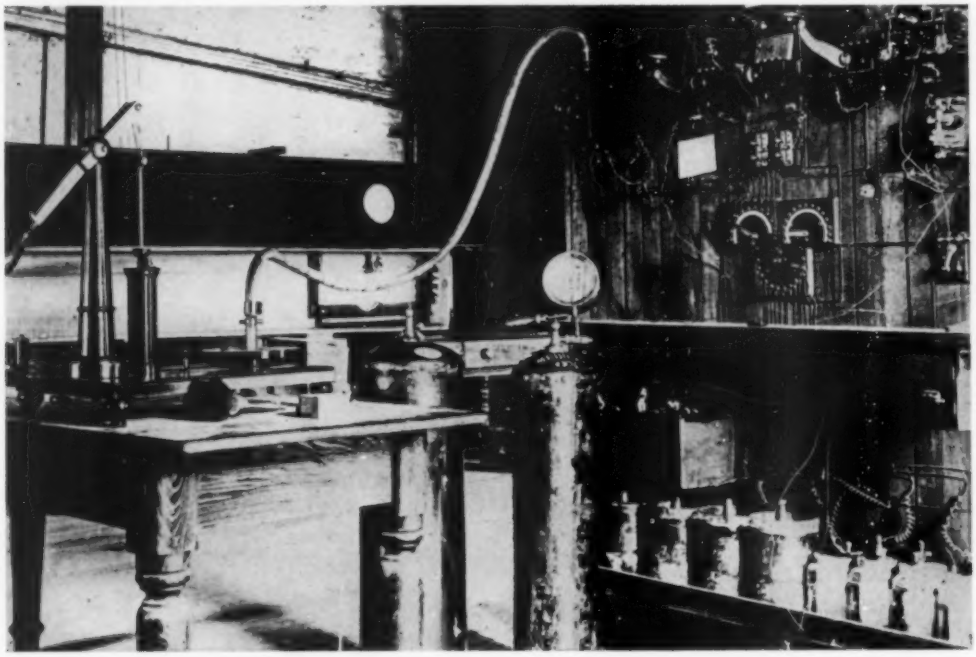
ANOTHER MILESTONE in the year 1904 was the development and commercial application of the first successful telephone repeater, invented by H. E. Shreeve, of Mr. Hayes's department.

The idea of inserting in a line one or more repeaters—or relays as they were called at first—to reinforce the weakened telephone current from a local source of energy was almost as old as the telephone itself. Many such devices had been invented, both within and without the Bell System, but none were satisfactory because of poor articulation, irregular operation, and singing.

The Shreeve repeater was of the mechanical type, in which the working parts of a telephone receiver and transmitter were combined in one instrument. By careful refinements in design, Shreeve was able to so reduce the inertia of the working parts that he succeeded where others had failed.

In August, 1904, the first commercial application of the Shreeve repeater was made at Pittsburgh on an open-wire circuit between Chicago and New York. Substantial improvements were made in this repeater in the years that followed, and it was used in the Bell System to a limited extent until superseded by the vacuum-tube repeater.

It was not until Arnold's improvement of the deForest audion, which led to the high-vacuum electronic tube in 1913, that a satisfactory vacuum-tube repeater became available. This was not due to a failure



A corner of the Mechanical Department laboratory at 127 Purchase Street about 1890

to recognize the possibilities of electronic amplification or to lack of efforts to achieve it by the members of Mr. Hayes's department. As early as 1896, stirred by the recent invention of the X-ray tube, John Stone Stone undertook studies and experiments of ways of utilizing the X-ray or similar tubes as a telephone relay. Similar studies were begun in 1904 of methods of using the mercury-vapor arc—invented by Peter Cooper Hewitt—as a telephone amplifier; and in 1906 and 1907, G. A. Campbell and T. C. Hebb studied the negative-resistance characteristics of the electric arc with a similar objective in view.

Far-sighted Investigations

THIS WAS by no means the first instance where the far-sightedness of Mr. Hayes stimulated investigations that were so much in advance of their time that immediate practical results could not be obtained. In 1892, only a few years after the discovery of Hertzian waves and before Marconi's demonstration of wireless telegraphy, Mr. Hayes set John Stone Stone to work to see "if it might be possible to signal vessels at sea by means of electrical oscillations of high frequency transmitted to them through space without wires." In the Spring and Summer of 1892, Stone made a number of experiments in high-frequency transmission, both over wires and through space: the first attempts of the Bell System at carrier and radio telephony. Stone was partially successful in the wire side of this work; he failed in the radio side of it because of the lack at the time of a suitable high-fre-

quency generator and a radio detector.

IT WAS also during these years that Mr. Hayes undertook studies of mechanical switching methods. The work began as early as 1888, but at first it was concerned chiefly with switching systems for the smaller offices, since to give 24-hour service with operators when only a comparatively few lines were involved inevitably meant excessive costs. By the beginning of the twentieth century, however, the situation was changed. The rapid growth of the telephone business in the large cities indicated that the greatest need for mechanical switching would be in the major centers, and by 1905 work was being actively prosecuted on a 10,000-line semi-mechanical switching system by Mr. Hayes's department in coöperation with the engineers of the Western Electric Company.

During the following years, work upon the design of mechanical switching equipment, of both the rotary and panel types, was prosecuted actively by the Western Electric Company, based upon the fundamental studies of requirements made by Mr. Hayes and his staff. Although several years elapsed before the semi-mechanical system was ready for commercial trial, and several more had passed before the final result—the full mechanical panel dial system—was installed in commercial service in the Bell System, a substantial amount of progress was made during the first few years on the design of the apparatus and circuits employed in this highly intricate power-drive system. Worthy of special mention in this early work are E. B. Craft, J. L. McQuarrie, A. F. Dixon, and F. R. McBerty, of the Western Electric Company; W. G. Blauvelt and E. C. Molina, of the A. T. & T. Company; and A. M. Bullard, who was employed at different times by both companies.

AMONG the many other projects carried on during this period was the development of methods of electrical protection. When the telephone came into commercial use, the only protective devices required were simple metal cut-outs to protect against lightning. These were inherited from telegraph practice. The growth of electric lighting systems, begun in the early 1880s, introduced new hazards: the danger of fire and other damage to the delicate telephone apparatus due to the possibility of accidental contact between the telephone wires and the high-voltage electric light wires. A new system of protection had to be devised. After a thorough analysis and considerable experimental work, Mr. Hayes's staff designed three protective devices: the carbon block lightning cut-out to guard the line in the presence of high voltage; the fuse to open the line in the presence of large currents; and the "heat coil" to protect the apparatus against comparatively small currents that were yet large enough if maintained over periods of time to damage the apparatus. In substantially unchanged form, these devices have continued in use to the present day.

Mr. Hayes's organization also undertook elaborate investigations into inductive coördination, into electrolysis effects and possible remedial measures, and into the development of

HEADQUARTERS TECHNICAL STAFF
AMERICAN BELL TELEPHONE COMPANY
DECEMBER 31, 1895
81 EMPLOYEES

ENGINEERS DEPT. JOSEPH P. DAVIS, CHIEF ENGINEER	MECHANICAL DEPT. H. V. HAYES, ELECTRICAL ENGINEER	EXPERIMENTAL DEPT.
CONDUIT PLANS AND DEVELOPMENT STUDIES: W. S. FORD J. A. HIGHLANDS B. W. TRAFFORD J. WYMAN TOLL TRAFFIC STUDIES: T. B. DOOLITTLE G. T. BLOOD T. COTTER A. J. DELANO J. A. McCABE R. A. NICHOLS BUILDINGS: L. F. RICE INSURANCE: C. J. H. WOODBURY INSPECTION: C. H. CUTLER DRAFTING: A. V. EDWARDS CLERICAL: S. H. MILDRAM M. J. HEANEY O. W. HOLLIS	TELEPHONE TRANSMISSION: W. L. RICHARDS J. S. STONE SWITCHBOARD ENGINEERING: L. S. GREENLEAF E. SLADE T. C. WALES, JR. W. R. WESCOTT A. S. WILLIAMS MECHANICAL CONSTRUCTION AND DESIGN: C. H. ARNOLD J. S. CODMAN A. DEKHOTINSKY F. C. MOODY E. C. ROBES G. K. THOMPSON GENERAL ENGINEERING: F. L. RHODES CHEMICAL LABORATORY: J. C. LEE G.O. BASSETT WIRE INSPECTION: 3 INSPECTORS SHOP: 7 MACHINISTS DRAFTING: 7 DRAFTSMEN CLERICAL AND STUDENTS: 8 EMPLOYEES INSTRUMENT TESTING AND PACKING: 18 EMPLOYEES	W. W. JACQUES J. H. FLANNIGAN H. R. MASON

rules for the joint use of poles. Cooperation with other interests for the preparation of the National Electrical Code was also begun.

Many other developments of this period, such as the bridging station bell, four-party full-selective signaling, and machine ringing, although not originating in Mr. Hayes's department, were applied by it and improved under his direction. Although Mr. Hayes's work was primarily the direction of the studies and research of others, he never lost close contact with each project, and played an important role in many of the developments himself. His name appears as principal or associate on twenty-one United States patents issued between 1885 and 1907.

Developing an Organization

AN IMPORTANT PHASE of Mr. Hayes's work was his development of the staff organization to meet broadly the engineering and operating requirements of the Associated Companies of the System.

He visualized that the companies would do the detailed engineering and operating work, with the Engineering Department confining itself, in addition to its fundamental engineering studies, to the preparation of standard specifications, data and methods for fundamental planning, bulletins on uniform operating practices, and maintenance instructions. It was to this end that he reorganized the department from time to time as specialization required; diverted functions properly belonging to other parts of the System, such as the inspection of construction material to the Western Electric Company; and separated technical and fundamental development work from the engineering side.

An example of this staff organization development is in the traffic department.

In 1899, Hayes pointed out the divergence of opinions among the operating companies as to permissible circuit and operator loads and other traffic matters, and the need for the Engineering Department to keep itself so informed as to be able to speak authoritatively on all points relating to operating practices. With this in view, he set up a separate department in traffic engineering; and while progress was made in succeeding years, he stated in 1905 that there was no field of development work requiring more earnest attention than the improvement in toll operating methods. He remarked on the waste of circuit time caused by operating irregularities, and the lack of speed, accuracy, and cost standards for measuring work in the different territories.

IT WAS IN 1905 that he put K. W. Waterson in charge of traffic engineering, who with Mr. Hayes's support pioneered in the development of the traffic unit system which provided a useful tool for calculating force requirements, and loads which could be carried while giving satisfactory service.

Service observing methods, simplification of toll and local operating methods, and systematized toll line

Opposite: Organization chart of the headquarters technical staff of the American Bell Telephone Company in 1895

and switchboard engineering practices also resulted from the importance which Mr. Hayes assigned to traffic matters.

As brought out in the Annual Reports to Stockholders of the late 1880s and early 1890s, the matter of rate reductions had been from the outset a problem requiring closest attention, not only from the point of view of placing telephone service within the reach of more and more persons, but also with the view of answering such general criticisms as those of the prevailing rate structures. It is not surprising, therefore, to find Hayes stressing the importance of operating economies; of developments in connection with metered service, party-line service, and machine ringing; and of reducing manufacturing costs of all items of equipment. As the result of such activities, the Annual Report for 1905 could mention that the marked reductions in rates over the past few years were due largely to the constant decrease in investment per station as a result of the introduction of sound engineering and construction methods and of the development of new classes of service, and to the year-by-year lowering of the average cost of operation per station.

Mr. Hayes's Later Years

MR. HAYES withdrew from active service in the Bell System on July 1, 1907, just prior to the removal of the parent company's headquarters from Boston to New York, but he continued as consulting engineer of the parent company until 1913. During this period and for the following eleven years he also served as a consultant for many other firms, and published two books, "Public Utilities—Their Cost New and Depreciation," and "Public Utilities—Their Fair Present Value and Return."

He was a leader in developing and improving devices for detecting the presence of submarines, and of instruments for transmitting underwater signals, and served as a lieutenant in the Navy during the first World War. One of the firms for which he acted as consultant after 1907 was the Submarine Signal Corporation of Boston, of which he later became Chief Engineer, and from 1924 to 1930, President. During this latter period he was active in developing a navigation instrument for registering the depth of the ocean directly beneath a ship.

After his retirement from active work, in 1930, he investigated methods of signaling through fog by means of infra-red rays.

MR. HAYES was a Fellow of the American Institute of Electrical Engineers, which he joined in 1889, and of the American Academy of Arts and Sciences, and a member of the Institute of Radio Engineers, the Acoustical Society of America, the Union Club of Boston, and the University Club of New York. During recent years he had maintained an office and laboratory at 253 Summer Street, Boston.

His residence at the time of his death—48 Beacon Street—is only a few minutes' walk from the site of the Williams machine shop at 109 Court Street, where the telephone was born, and from 101 Milk Street, 141 Pearl Street, 127 Purchase Street, 42 Farnsworth Street, and 19

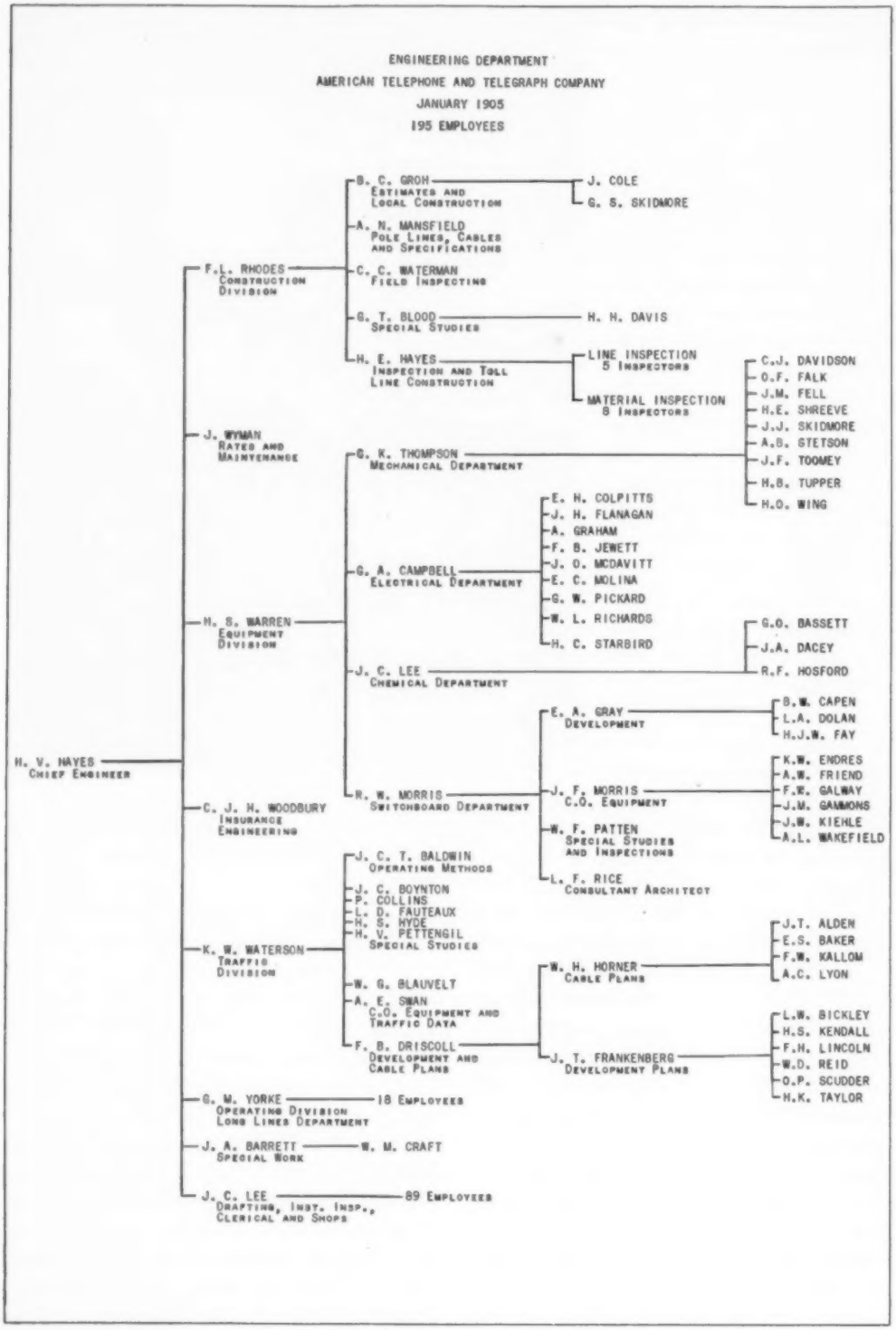
Oliver Street where the Mechanical Department and its successor organizations carried on its work while Mr. Hayes was at its head.

Although housed in humble quarters and with a comparatively small staff by present-day standards, the research and development organization directed by Mr. Hayes from 1885 to 1907 was, as has been indicated earlier, the forerunner of the present Bell Telephone Laboratories in both function and purpose.

In a way, the telephone itself was a product of a development laboratory—but with a difference. Bell and Watson, struggling with the problems of the telephone in a small room in Williams' machine shop at 109 Court Street, Boston, were isolated workers seeking the solution of a single problem. To a large extent, both were practical inventors; they were not carrying on research, nor were they, in the usual sense of the word, developing. When Mr. Hayes took over the recently formed Mechanical Department, however, the telephone was already in practical use; what was badly needed was the development of circuits, apparatus, and systems that would improve the service and extend its scope. Research was also needed to disclose hidden relationships and laws on which future improvements might depend.

The common battery switchboard installed at Lexington, Mass., in 1893—the first common battery switchboard used commercially

MR. HAYES was eminently suited to carry on work of this type. One of his Boston associates, in close contact with him for a number of years, spoke of him thus: "A man of means and culture, representative of the best New England traditions, he was at once a scholarly scientist and an enthusiastic leader of his small band of technical workers." And he added that: "Distinguished for sincerity, honesty, and candor, he was singu-


ENGINEERING DEPARTMENT
AMERICAN TELEPHONE AND TELEGRAPH COMPANY
JANUARY 1905
195 EMPLOYEES
H. V. HAYES
Chief Engineer
F. L. RHODES
Construction Division
B. C. GROH
Estimates and Local Construction
J. COLE
G. S. SKIDMORE
A. N. MANSFIELD
Pole Lines, Cables and Specifications
C. C. WATERMAN
Field Inspecting
G. T. BLOOD
Special Studies
H. H. DAVIS
H. E. HAYES
Inspection and Toll Line Construction
LINE INSPECTION
5 Inspectors
MATERIAL INSPECTION
8 Inspectors
C.J. DAVIDSON
O.F. FALK
J.M. FELL
H.E. SHREEVE
J.J. SKIDMORE
A.B. STETSON
J.F. TOOMEY
H.B. TUPPER
H.O. WING
J. WYMAN
Rates and Maintenance
G. K. THOMPSON
Mechanical Department
H. S. WARREN
Equipment Division
G. A. CAMPBELL
Electrical Department
E. H. COLPITTS
J. H. FLANAGAN
A. GRAHAM
F. B. JEWETT
J. O. MCDAVITT
E. C. MOLINA
G. W. PICKARD
W. L. RICHARDS
H. C. STARBIRD
J. C. LEE
Chemical Department
G.O. BASSETT
J.A. DACEY
R.F. HOSFORD
R. W. MORRIS
Switchboard Department
E. A. GRAY
Development
B.W. CAPEN
L.A. DOLAN
H.J.W. FAY
J. F. MORRIS
C.O. Equipment
K.W. ENDRES
A.W. FRIEND
F.W. GALWAY
J.M. GAMMONS
J.W. KIEHLE
A.L. WAKEFIELD
W. F. PATTEN
Special Studies and Inspections
L. F. RICE
Consultant Architect
C. J. H. WOODBURY
Insurance Engineering
K. W. WATERSON
Traffic Division
J. C. T. BALDWIN
Operating Methods
J. C. BOYNTON
P. COLLINS
L. D. FAUTEAUX
H. S. HYDE
H. V. PETTENGIL
Special Studies
W. G. BLAUVELT
A. E. SWAN
C.O. Equipment and Traffic Data
F. B. DRISCOLL
Development and Cable Plans
W. H. HORNER
Cable Plans
J.T. ALDEN
E.S. BAKER
F.W. KALLOM
A.C. LYON
J. T. FRANKENBERG
Development Plans
L.W. BICKLEY
H.S. KENDALL
F.H. LINCOLN
W.D. REID
O.P. SCUDDER
H.K. TAYLOR
G. M. YORKE
Operating Division Long Lines Department
18 Employees
J. A. BARRETT
Special Work
W. M. CRAFT
J. C. LEE
Drafting, Inst. Insp., Clerical and Shops
89 Employees

larly well qualified to direct the Bell System's early technical activities." He also spoke of the extraordinary skill and far-sightedness with which Mr. Hayes's task was carried on, handicapped as it was with very limited funds and personnel.

A letter addressed to him on his retirement and individually signed by 136 of the leading members of the Engineering Department says: "We, who have served as your assistants in the Engineering Department of the American Telephone and Telegraph Company, are moved to express the respect and esteem which every member of this Department has felt under the inspiration of your leadership. Through your high attainments as an engineer and the keen personal interest you have shown toward each of us individually, the Department has been lifted to its present high standard of efficiency and enthusiasm in its service to the Company. We feel that it has been our good fortune to have served under the standard which you have upheld, and we wish, with respect and sincere affection, to testify to the high ideals which you have constantly set before us."

No one man, of course, can solve all the problems of even so small an organization as was the Bell System at that time. One of the true evidences of the able direction of research and development is the ability to select suitable men to carry on various phases of the work and to stimulate them to the highest achievement by appreciation and encouragement. Evidence of Mr. Hayes's ability in this direction is the large number of men of his organization who have since made individual names for themselves in the telephone industry. A list of a few of those who are still active, or were until recent years, will suggest a much more extensive list to those familiar with the earlier days of telephone development. O. B. Blackwell, G. T. Blood, G. A. Campbell, H. P. Charlesworth, F. J. Chesterman, E. H. Colpitts, H. E. Darling, R. S. Hoyt, F. B. Jewett, E. C. Molina, R. W. Morris, F. L. Rhodes, W. L. Richards, H. E. Shreeve, G. K. Thompson, J. F. Toomey, H. S. Warren, and K. W. Waterson are all names of outstanding significance in the telephone industry, and they all served under Mr. Hayes.

Opposite: Organization chart of the Engineering Department of the American Telephone and Telegraph Company in 1905

Twenty-five Years Ago in the BELL TELEPHONE QUARTERLY

Items from Volume I, Number 3, October 1922

Death of Dr. Bell

AMONG the most impressive of the tributes to the memory of Alexander Graham Bell, who died on August 2, was that of the telephone system which bears his name.

As the body of the inventor was being laid at rest on the summit of Beinn Bhreagh, near his summer home at Baddeck, Nova Scotia, on August 4, service was suspended for one minute on all lines of the American Telephone and Telegraph Company and its associated companies, both in the United States and Canada.

Memorial resolutions were passed by the Directors of the American Telephone and Telegraph Company at a meeting held on August 15. Quite fittingly, this tribute is recorded as coming not merely from the Bell System as an organization, but on behalf of the hundreds of thousands of telephone workers of the world.

The resolutions follow:

"In the death of Alexander Graham Bell the civilized world mourns for a man who thought fearlessly, worked tirelessly and served generously to relieve the unfortunate and to benefit humanity.

"He was the inventor of the telephone because his thoughts adventured into new and untried fields of science, because his enthusiasm for discovery was sufficient to overcome all difficulties, because his practical mind demanded a consummation of his theories in practical results, and because he was inspired to contribute greatly to the common good.

"As an investigator he was intelligent beyond the genius of his age. In the invention of the telephone he founded the art of transmitting speech electrically, a new and invaluable contribution to the humanizing of mankind.

"He was one of the few in history who lived to see the child of his brain developed into a world-wide service. This was the only reward he sought and this reward was fully his.

"Whereas, this company was founded upon and is devoted to the development of his invention for the service of humanity, it seems proper that we, the directors of the American Telephone and Telegraph Company, for ourselves and in behalf of the men and women of the Bell System should spread upon our records our recognition of the debt owed to Alexander Graham Bell by the hundreds of thousands of telephone workers of the world for the opportunity for service which his invention made possible."

From "Notes on Recent Occurrences."

Dr. Bell's Telephone Service

DEAR MR. CARTY:

I am beginning to get distressed over the many statements the papers have been publishing of Mr. Bell's dislike of the telephone.

Of course, he never had one in his study. That was where he went when he wanted to be alone with his thoughts and his work. The telephone, of course, means intrusion by the outside world.

And the little difficulties and delays often attending the establishment of conversation in even well managed telephone circuits did irritate him, so that as a rule he preferred having others send and receive messages. But all really important business over the telephone he transacted himself.

There are few private houses more com-

pletely equipped with telephones than ours at 1331 Connecticut Avenue, and there was nothing that Mr. Bell was more particular about than our telephone service here. [Beinn Bhreagh, N.S.]. For nearly all of the thirty-five odd years we have been here he saw personally to its proper working. We never could have come here in the first place or continued here, but for the telephone which kept us in close touch with doctors and neighbors and the regular telegraph office. . . .

Mr. Bell did like to say in fun, "Why did I ever invent the Telephone," but no one had a higher appreciation of its indispensableness or used it more freely when need was—either personally or by deputy—and he was really tremendously proud of it and all it was accomplishing. He appreciated the honor of being first to talk from New York to San Fancisco, was awed by the wonder of its performance at that dinner at the New Willard, followed with interest its usefulness during the war, and the development shown at Arlington last autumn.

Mr. Bell's one regret about the telephone was that his wife could not use it or follow his early work in sound.

I honestly believe this had much to do with his not going on with the photophone experiments and engaging instead in aerial work the progress of which I could see as well as he.

I shall always be so thankful that the telephone worked so well that last day—serving its father so loyally.

Yours very sincerely,

MABEL G. BELL

August 24, 1922.

From "Notes on Recent Occurrences."

Experimental Broadcasting Service

ON OCTOBER 2ND the original license was superseded by one granting permission to broadcast on 400 meters. As a result, a new time schedule has gone into effect assigning the afternoon hour from 4:30 to 5:30 every week-day and the evenings from 8 to 10 on Monday, Wednesday, Thursday and Saturday.

Beginning July 25th when the first license was issued, steps were taken to interest prospective users of these broadcasting facilities. The results obtained up to October 2nd were very encouraging but it was apparent that a license to operate only one night a week constituted a very real handicap to the building up of business. The new time schedule with permission to use a wave length of 400 meters has materially improved this situation. With a desirable hour every afternoon and four evenings a week every effort will be made to popularize this new radio service, and it is expected that in the near future evidence will be at hand indicating how extensively it will be used by the public.

From "Notes on Recent Occurrences."

World's Telephone Statistics

ON JANUARY 1, 1921, there were 20,850,550 telephones in the world; of these 13,329,379, or 64%, were in the United States and 12,601,935, or 60% were connected to the Bell System. The number of telephones in all the countries of Europe combined was 5,289,606, or 25% of the world's total; all other countries had 2,231,565 telephones, or only 11% of the world's total. During the seven years 1914 to 1920, inclusive, 5,962,000 telephones were added to the telephone systems of the world, an increase of 40%. The total number of telephones at the beginning of 1921 was equivalent to 1.2 instruments for each 100 of the world's population.

From an article by S. L. Andrew, former A. T. & T. Chief Statistician.

(Continued from page 111)

in February of this year. His uniform bears many decorations awarded him by three countries. He contributed "A War Game Test of Telephone Service" to the QUARTERLY for January 1939.

AS THE ravages of the recent war are repaired, communications are increasingly restored—and facts about them become more readily available. Thus, JAMES R. MCGOWAN'S discussion of telephone statistics in this issue is considerably fuller and more complete than his "Telephones in the Post-War World," in the MAGAZINE

James R. McGowan

for Autumn 1946 could be. His ten years of A. T. & T. service with the Chief Statistician's Division, devoted to studying and reporting on the statistics and economics of foreign telephone development, were interrupted by more than four years of military duty, spent in statistical and administrative work with the Signal Corps in Washington and with the Economics Division of Military Government in Berlin.

TURNING BACK the pages of history half a century, ROGER B. HILL and THOMAS SHAW appraise and acclaim the contributions to the development of the Bell System made by one man: Hammond V. Hayes.

Mr. Hill entered the Engineering Department of the American Telephone and Telegraph Company in 1911, and for several years thereafter was engaged principally in appraisal and depreciation studies. When the Department of Development and Research was formed in 1919, he transferred to it, and since then has been largely concerned with studies of the economic phases of development and operation. He has been a member of the staff of the Bell Telephone Laboratories since 1934, first in the Outside Plant Development Department and later in the Staff Department. In addition to his work on the economic side of the telephone business, Mr. Hill has taken great interest in the early history of the telephone art, and has assisted with the preparation of several books and articles dealing with that subject.

Memories of the inspiring personality and leadership of Hammond V. Hayes contribute greatly to the satisfaction Mr. Shaw derives in writing of some of the work carried on under Mr. Hayes's direction. Joining Mr. Hayes' department after graduation from M. I. T. in 1905, Mr. Shaw was included in the transfer of the Engineering Department from Boston to New York, following the general reorganization in 1907. For more than a decade thereafter, he engaged in the development of transmission apparatus, including loading coils. He became a charter member of the Department of Development and Research when it was organized in 1919, and joined the Bell Telephone Laboratories in the 1933 amalgamation. As loading engineer, he has since been concerned chiefly with problems of telephone-circuit loading, including the transmission and economic aspects of the loading apparatus.

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